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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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BOILER FEED PUMPS.
See advertisement pages 29 and 77.
PATENT WATER-TUBE BOILERS; AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

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FLOATING CRANES. COAL BUNKERING VESSELS.
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See Advertisement last week, page 101.

S. Sokal, CHARTERED PATENT AGENT.
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T.N. 4815 Museum. 9675

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
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See page 17. 9108

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For Paraffin and Crude Oil.
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Tubes and Fittings.
Sole Licencees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 8746
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 83, Dec. 9.

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SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 9563
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Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
Spur Wheels cut up to 9 ft. diam.
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Yachts, Launches or Barges
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3561
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SYSTEMS { PRESSURE, AIR, STEAM.
FOR BOILERS OF ALL TYPES.
Kermodes Limited,
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Telephone No.: Museum 6684.
NAVAL OUTFITS A SPECIALTY.

Locomotives Tank Engines
designed and constructed by MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 2487
See their Illus. Advertisement, page 107, last week.
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BUILDERS of RAILWAY CARRIAGES & WAGONS, MAKERS of WHEELS and AXLES of all kinds.
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AUCTIONEERS, VALUERS AND SURVEYORS for ENGINEERING AND ALLIED TRADES and INDUSTRIAL PROPERTIES. 9866
63 and 64, CHANCERY LANE, LONDON, W.C.2.

Electric Lifts
(UP TO 35 TONS.) 9863
S. H. HENYWOOD & CO., LTD. REDDISH.

John H. Wilson & Co., Ltd.,
Birkenhead.
See Illustrated Advertisement Page 100, Jan. 28.

Locomotive Shunting Cranes

Steam and Electric Cranes
EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS, SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 9364
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London Office: 15, VICTORIA STREET, S.W.1.

John Bellamy, Limited,
MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes and Fittings.

Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 98. 9091

Machine and Engineering
WORK of all descriptions undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT ACT.—ROSSER & RUSSELL, LTD., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 9211

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GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES, CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 9241

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS.
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London Office: 14, Leadenhall Street, E.C. Od3382

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Telephone: Central 7424. Od 585
ON ADMIRALTY LIST.

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London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice Making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 9604

Electric Cranes.
S. H. HENYWOOD & CO., LTD., REDDISH. 9862

The National Foremen's ASSOCIATION OF THE ENGINEERING AND ALLIED TRADES. (Registered under the Trade Union Act.)
An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. F 601
All communications to— H. W. REID, General Secretary. Head Offices— 95, Belgrave Road, Victoria, London, S.W.1.

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Augustin-Normand
67, rue de Perrey—LE HAVRE (France). 2890
Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Royles Limited,
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FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES, } Row's Patents.
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SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5733

Yarrow Patent Water-tube Boilers. 9564
Messrs. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton,** 9518
See Full Page Advt., page 70, Dec. 9.

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Walter Somers, Limited,
HALESOWEN. 7116

Spur & Bevel Gear Generating ATTACHMENTS FOR SHAPERS.
Spur Gear 12 in. Straight & Spiral Bevels 6 in. and 9 in. Through Merchants only. 9704
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"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
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About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices. 8195
TAYLOR & CHALLEN, LTD., Engineers, Constitution Hill, BIRMINGHAM.
See Full page Advertisement page 68, Dec. 9.

FOR **Drop Forgings** write
GARTSHERRIE ENGINEERING & FORGE CO., 80, Wellington Street, Glasgow. 0674

"Spencer-Hopwood" Patent WATER TUBE **Boilers.** *See page 88.* 9393
Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

GRAPHITED OIL. **"OILDAG"** (Reg.) BRAND.
GRAPHITED WATER. **"AQUADAG"** (Reg.) BRAND.
GRAPHITED GREASE. **"GREDAG"** 9508

E. G. Acheson Ltd.,
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Locomotive Traversers (HLECTRIC). 9689
S. H. HENYWOOD & CO., LTD., REDDISH.

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION, RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, GLASGOW. Od 3547
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Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 9737
See half-page Advertisement page 76, Nov. 25.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by SIR WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 9310

Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to MR. TREVOR W. PHILLIPS, B.Sc. (Hons.), Assoc.M.Inst.C.E., M.R.S.I., etc., 8-10, Trafford Chambers, 58, South John Street, Liverpool. 9296

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.E.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 9614

Inst. C.E. Exams.—Successes

as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 26 years' professional experience. Address, 7434, Offices of ENGINEERING.

TENDERS.

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply

of:—

BORING MACHINES.

Forms of Tender may be obtained from the Director - General, India Store Department, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than Two o'clock p.m., on Tuesday, the 3rd January, 1922.

T. RYAN,
Director-General. S 89

METROPOLITAN WATER BOARD.

SUPPLY OF APPROX. 1112 FT. OF 48 IN. DIA. SOCKET AND SPIGOT LAPWELDED STEEL TUBE IN 16 FT. AND 8 FT. LENGTHS.

The Metropolitan Water Board invite

Tenders for the Supply of

67 16 ft. and Five 8 ft. lengths of 48 in. dia. SOCKET and SPIGOT LAPWELDED STEEL TUBE, AND TWO BENDS, required for various railway and river crossings on the line of the 48 in. main, Walton to Honor Oak (Sections Nos. 1 and 2). The Steel is to be of good ductile quality of British manufacture, made by the open hearth process, of tensile strength of 24 to 28 tons per square inch, and shall comply in every respect with the British Standard Specification.

Forms of Tender, Conditions of Contract, Specification and Drawings, etc., may be obtained on personal application at the Offices of the Board (Room 136), New River Head, 173, Rosebery Avenue, E.C. 1, or upon forwarding a stamped addressed brief envelope.

Tenders, enclosed in sealed envelopes addressed to "The Clerk of the Board, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C. 1," and endorsed "Tender for 48 in. dia. Steel Tubes," must be delivered at the Offices of the Board, not later than Ten a.m., on 10th January, 1922.

The Board do not bind themselves to accept the lowest or any Tender.

W. MOON,
Clerk of the Board,

Offices of the Board,
New River Head,
173, Rosebery Avenue,
E.C. 1.

12th December, 1921. S 906

COUNTY BOROUGH OF CROYDON.

BOROUGH HOSPITAL, WADDON.

TO BUILDERS, HEATING ENGINEERS, BOILER MAKERS, Etc.

Notice is Hereby Given that the Council are prepared to receive

Tenders as follows:—

CONTRACT No. 1.—BUILDERS' WORK in connection with forming Pipe Ducts in Corridors, Boiler Foundations, and sundry other works at the Borough Hospital.

CONTRACT No. 2.—The Supply, Delivery and Fixing of additional STEAM CIRCULATING MAINS, PUMPS, VALVES, and other Steam Fittings, etc., in the existing Boiler House, Corridors and Blocks at the Borough Hospital.

CONTRACT No. 3.—The Supply, Delivery and Fixing of ONE STEEL LANCASHIRE BOILER in the existing Boiler House at the Borough Hospital.

Conditions of Contract, Drawings, and Specification may be seen on application to the Borough Engineer, Town Hall, Croydon, and copies of quantities, etc., obtained on receipt of a deposit of two guineas in respect of each contract, which will be returned on receipt of a *bona fide* Tender.

Tenders on the prescribed forms to be sent to me by Eleven o'clock in the Forenoon on FRIDAY, the 6th day of JANUARY, 1922, endorsed "Tender for Builders' Work, Borough Hospital."; "Tender for Steam Circulating Mains, etc., Borough Hospital"; or "Tender for Steel Boiler, Borough Hospital," as the case may be.

Tenders will only be received subject to the terms of the Draft Contract, General and Special Conditions, deposited at my office, and which may be inspected during office hours.

The Council will not be bound to accept the lowest or any Tender.

J. M. NEWNHAM,
Town Clerk.

Town Hall, Croydon.
6th December, 1921. S 881

The Pocklington U.D. Council

Invite TENDERS for the Purchase of One Merryweather's Patent light County Council pattern Steam Fire Engine of 300 gals. per minute capacity, with accessories, being replaced by larger Engine. Detailed particulars on application. Tenders by 31st December to CLERK TO COUNCIL, Railway Street, Pocklington. S 905

LONDON COUNTY COUNCIL.

Tenders are Invited for the

PROVISION and ERECTION of an ELECTRIC PASSENGER LIFT, capable of dealing with a load of 11½ cwt., to have full automatic push-button control, to be completed within two months—at Geoffrey House, Tabard Garden Estate, Bermondsey, S.E. 1.

The Specification, Form of Tender, etc., may be obtained on and after Monday, 19th December, 1921, from the Chief Engineer of the Council, at Gloucester House (Room 91, 6th floor), 19, Charing Cross, W.C., after payment to the Cashier of the Council of £1. This amount will be returnable only if the Tenderer shall have sent in a *bona fide* Tender, and shall not have withdrawn the same. The contract documents may be inspected before the payment of the fee.

No Tender received after Four p.m. on Thursday, 12th January, 1922, will be considered. The Council does not bind itself to accept any Tender.

JAMES BIRD,
Clerk of the London County Council. S 909

THE BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of:—

(A) SIX 4-Wheeled GOODS BRAKE VAN UNDERFRAMES.
47 BOGIE QUADRUPLE BOLSTER WAGONS.
(B) 200 PAIRS WHEELS complete with Axles for above.

For each copy of the Specification (A), a fee of 20s. will be charged, and for each copy of the Specification (B), a fee of 10s. will be charged, which fees are not returnable. Tenders enclosed in sealed envelopes addressed to the "Chairman and Directors," and endorsed "Tender for Underframes and Wagons" or "Wheels," as the case may be, must be delivered at the Company's Offices, not later than Twelve noon, on Thursday, 5th January, 1922. The Directors do not bind themselves to accept any or the lowest Tender, and reserve the right to divide the order.

By Order of the Board,
F. C. FRANKS,
Secretary.

199, Gresham House,
Old Broad Street,
London, E.C. 2.
14th December, 1921. S 893

APPOINTMENTS OPEN.

COUNTY BOROUGH OF CROYDON.
EDUCATION COMMITTEE.

Wanted, Teacher of Machine

Construction, Wednesday Evenings, 7.30 to 9.30 from January 11th. Fee 21s. per attendance State full particulars of education, training, age, experience, and present appointments, to the PRINCIPAL, Central Polytechnic, Scarbrook Road, Croydon.

JAMES SMYTH,
Clerk to the Committee.
5th December, 1921. S 837

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

There is a Vacancy in a

DEMONSTRATORSHIP in the Department of Mathematics and Mechanics in the Royal College of Science, South Kensington, S.W. 7. The appointment will be made as from the beginning of January, 1922, under the College conditions attaching to the office of Demonstrator, and the stipend will be at the rate of £300 per annum. The Demonstrator will have to take part in the teaching of Mathematics and Mechanics; and it is desirable that he should have had Workshop and Drawing Office experience.

Applications should be addressed to Professor A. R. FORSYTH, F.R.S., at the Imperial College. S 894

SWINDON AND NORTH WILTS TECHNICAL INSTITUTION.

Principal:—G. H. BURKHARDT, M.A. M.Sc.

Applications are Invited for

the following POSTS from graduates in Engineering. Both works experience and teaching experience are essential:

(1) HEAD OF ENGINEERING DEPARTMENT, who should be well-qualified in Mechanical Engineering.
Salary according to Burnham Scale with initial addition of £30 per annum for special responsibility and three-quarter "carry-over" as from September 1921.
(2) ASSISTANT LECTURER IN ENGINEERING, who should be well-qualified in Electrical work.
Salary according to Burnham Scale with three-quarter "carry-over" as from September, 1921.

Further particulars and forms of application (to be returned not later than the 17th December) may be obtained from the PRINCIPAL, Technical Institution, Swindon.

W. SEATON,
Secretary. S 825

CEMENT WORKS—INDIA.

Wanted, as Assistant General

Manager for large Cement Works in India, QUALIFIED ENGINEER, with a complete knowledge of the manufacture of Cement (wet process). Three years' agreement, free unfurnished quarters. —Write, giving full particulars of experience and salary required, to Z. C. 343, care of DEACON'S Leadenhall Street, E.C. 3. S 891

Works Manager with Ability

REQUIRED for important works with about 1,000 employees in normal times, devoted to the production of a high class engineering specialty. Must have sound experience in controlling staff and be thoroughly conversant with up-to-date machine shop practice for medium and heavy work, including gear cutting of all descriptions. Applicants should be possessed of broad outlook and be capable of obtaining high class production on the most economical lines. Elaborate systems and expensive organisation undesirable. Applications in strict confidence, stating salary expected, age and brief outline of experience. Only first class men who have made a success in a similar position should apply.—Address, ENGINEERING, WM. PORTEOUS & CO., Advertising Agents, Glasgow. S 899

Salesman Wanted for Pushing

Iron and Steel Works Plant, i.e., furnaces of all kinds with their accessories, gas producers, rolling mills, etc. Must be technically trained, live men of good address.—Address, stating age, experience and remuneration desired, S 844, Offices of ENGINEERING.

Civil Engineer for Rail-

way Construction, REQUIRED by the GOVERNMENT OF NIGERIA for two tours each of 12 to 18 months, service with possible extension. Initial salary £480 to £600 a year according to qualifications, rising by annual increments of £30. Commuted allowance of £12 a month payable in lieu of quarters. Outfit allowance of £60 payable on first appointment. Free first class passages. Liberal leave in England on full salary.

Candidates, preferably single, aged 25 to 35, must be fully qualified Civil Engineers who have had practical experience on Railway Survey and Construction.—Apply, at once, in writing, stating age and brief details of experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/Nigeria 11204. S 882

Civil Engineer Required

by the GOVERNMENT OF HONG KONG for three years' service as an Assistant Engineer in the PUBLIC WORKS DEPARTMENT, with prospect of permanency. Salary £460 a year, rising by annual increments of £20 to £600 per annum, with temporary addition of exchange allowance. Free passages provided.

Candidates, unmarried, age 25 to 30 years of age, must be A.M.Inst.C.E. and have had experience on the construction of waterworks, and in the use of concrete. Preference will be given to candidates who have been trained in a Waterworks Engineer's Office.—Apply at once, in writing, giving age and brief details of experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/Hong Kong, 11012. S 911

Civil Engineer Required

by the GOVERNMENT OF CEYLON for two years' service as an Assistant Engineer on the Harbour Works, Colombo, with prospect of permanency. Salary £700 per annum, plus a temporary increase of 25 per cent. (not to exceed £150 per annum), and a station allowance of 7½ per cent. of salary if unmarried, and 11 per cent. if married. Quarters not provided. Free passages.

Candidates, preferably single, must have had extensive experience in Harbour and Dock Construction, Dredging, etc., and possess organising and administrative abilities.—Apply at once, in writing, giving age and brief details of experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/Ceylon, 11245. S 913

Colonial Engineer

REQUIRED by the GOVERNMENT OF ST. VINCENT, BRITISH WEST INDIES, for three years' service with prospect of permanent and pensionable employment. Salary £360 per annum, with a travelling allowance of £60 per annum. Free passages. Good climate and moderate cost of living. Quarters not provided.

Candidates, preferably single, must be Civil Engineers and Surveyors, trained and experienced in the construction of roads, culverts, small bridges, public buildings, jetties, etc., and must possess a working knowledge of telephone instruments, switchboards and lines.

Apply, at once, in writing, stating age and brief details of experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting M/St. Vincent 11007. S 895

General Fitter Required

by the GOVERNMENT OF THE GOLD COAST for the PUBLIC WORKS DEPARTMENT, for two tours each of 12 to 18 months' service, with possible extension. Salary £500-£12-£560 per annum. Outfit allowance of £45 on first appointment. Quarters free of rent and free passages. Liberal leave in England on full salary.

Candidates, age 28-35, must have a thorough knowledge of motor engineering and be capable of carrying out all repairs required to keep American motor cars, lorries, etc., in proper running order. They must also be experienced in the running and maintenance of steam and internal combustion engines, electrical machinery and the usual woodworking and engineers' workshop machinery. Some sea experience in addition preferred.

Apply at once, by letter, stating age and particulars of experience and mentioning this paper, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W., quoting M/11084. S 912

Competent Car Engine

Designer (young), able invest about £1000 in highly profitable business. State fully experience, age, etc.—Address, S 838, Offices of ENGINEERING.

Engineer Wanted, One Used

to erecting machinery and well conversant with electric plant.—Address, S 889, Offices of ENGINEERING.

Production Engineer Required

for Engineering works in France. Must be thoroughly experienced in up-to-date production methods, speak and write French. Young man under 35 preferred. Initial monthly salary £25 to £40.—Write fullest particulars with references, copies, testimonials (no incomplete applications considered), L.G.C., 32, Temple Fortune Lane, London, N.W. 11. S 888

Handley Page Transport LIMITED.

The DIRECTORS of HANDLEY PAGE TRANSPORT LTD., INVITE APPLICATIONS for the POST of ENGINEER in charge of their repair shop and flying operations and of the engineering staff connected therewith. All applications will be treated in strict confidence and must state full details of applicant's past experience, age, salary required and when disengaged. Applicants must have had sound engineering training and good experience of flying operations and the repair and upkeep of aircraft.

HANDLEY PAGE TRANSPORT LTD., Cricklewood, London, N.W. 2. S 830

Senior Draughtsman, Ex-

Service (used to Automobile or similar work) WANTED. Wages, including Civil Service Bonus, 104/6 per week.—Apply, in writing, to SUPERINTENDENT, TANK DESIGN AND EXPERIMENT, Charlton House, Old Charlton, S.E. 7. S 886

Several Experienced

DRAUGHTSMEN REQUIRED accustomed to detail drawing and design of electrical apparatus. Applicants must give full particulars of previous experience and salary required.—MARCONI'S WIRELESS TELEGRAPH CO., Ltd., Chemsford. S 879

Wanted, Leading Draughts-

MAN experienced in Lifts and Cranes, capable of taking full charge of Drawing Office and able to get work through efficiently and expeditiously.—Apply, stating age, experience and salary required, to PICKERINGS LIMITED, Globe Elevator Works, Stockton-on-Tees. S 916

Required by Old-established

Firm of Engineers in India, One STRUCTURAL and One MECHANICAL DRAUGHTSMAN age about 25. Only single men with a thorough training and good experience need apply.—Reply fully, stating age, experience and salary required, to Z. Y. 339, care of DEACON'S, Leadenhall Street, London, E.C. 3. S 892

Leading Draughtsman

REQUIRED for turbine design, capable of taking full charge of Department, and working out general and detailed designs in accordance with latest developments.—Address, stating experience and salary required, S 884, Offices of ENGINEERING.

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MOBILE firm near London. Applicants must have had considerable experience in the fixing of times for all machining and assembly operations. — Address, stating particulars of experience, age, and salary required, S 920, Offices of ENGINEERING.

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Civil Engineer, 39, A.M.I.C.E.,

possessing highest qualifications, professionally and socially, for introducing business and undertaking special commissions where tact and knowledge of men and things is particularly desirable is free for service at home or abroad, permanently or temporarily. In strict confidence.—Address, S 785, Offices of ENGINEERING.

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BRITISH PATENTS; A LEGAL POINT.

IT is a requirement of British patent law and practice that a specification shall only cover one invention, although it may contain more than one claim. This is interpreted to a certain extent in different ways by the various examiners in the Patent Office and, in fact, from time to time the Office as a whole appears to inventors to vary the interpretation and application of the law. At the present moment the opinion is largely held that the Patent Office seek rather rigidly to enforce the doctrine of the single idea in a given patent. At one time, so long as the second and succeeding claims were made what is known as appendant to the main claim, that is to say, contained a definite limitation to that claim, very little regard was paid to the strength of the link connecting the two claims. It was considered that the limitation was sufficient to enable the Office to come to the conclusion that only a single invention was present, although there were more claims. Not only so, but where the art in question was small, quite independent claims were allowed to matters in the same art but otherwise not directly related. In other words, claims were allowed to different arrangements for fulfilling the same known function. Such claims are not allowed at the present day, or at least only in rare instances, and even the suggestion that unity of invention is shown where claims are appendant to a main claim is challenged. What the Office seek to find is that there shall be some definite connecting link between the appendant and the main claim, and if the substantive part of the appendant claim, that is to say, the particular point dealt with in that claim is applicable to apparatus or processes other than those dealt with in the main claim, then they strive to cause separate patents to be taken out, not being satisfied with the linkage of the claims it is intended to obtain by making the one appendant to the other. That being so, it is well for inventors to note what is probably the most important decision of modern times, and one on which the Patent Office largely rely, because this decision explains what are the cases in which one may claim that a single invention is present and what are the kinds of claim which have been rejected. The decision was given some years ago by Sir Samuel Evans, then the Solicitor-General, and is reported in R.P.C., vol. xxvii, on page 285.

An application was made by an inventor identified in this case as "Z" for a patent for automatic gas-operated machine guns. The application contains separate claims for special constructions of several well-known features in the guns, namely, the breech action, the change-fire device, the detent for the gas piston, the tension and releasing device for the operating spring, and so on. The Comptroller at a hearing decided that these could not be allowed in one application, although they were all applicable to one class of gun, and he required the specification to be divided into two parts, so that the firing mechanism should be the subject of a separate application. He held that different considerations would apply on the one hand to the case of improvements on a machine recently invented as a whole, and on the other hand improvements on a well-known type of machine in which there had been a continuous and extensive development of its parts.

On appeal the Solicitor-General upheld the decision of the Comptroller, and his judgment states:—

"If an application were made in such a well-known machine as the steam engine for improvements in the piston and the crank shaft these would clearly be distinct matters, whereas if the whole machine were new, a patentee would be allowed to claim all the parts separately in one patent."

In the case in question the whole of the matters comprised in the specification relate to automatic machine guns and the claims are limited to gas-operated machine guns, but the Comptroller pointed out that parts of the apparatus, though limited in the claims, could be equally well used in any automatic machine gun, wherefore the Solicitor-General upheld the decision that the firing mechanism should be regarded as a distinct matter from the gas-operated piston and cylinder. The Solicitor-General suggested that the breech mechanism might also reasonably have been asked to be separated, but this was not pressed. This case shows the extent to which different matters may be included in one application, and also how far separate ideas may not be covered by the same patent.

STRAIN FIGURES IN ETCHED STEEL.

IN investigating some failures and inferior performances of mild steel, for which neither chemical analysis nor examination by ordinary etching would account, Dr. Ing. A. Fry, of Essen, modified the method of etching by means of copper chloride, submitting the specimens also to a thermal treatment. The results, which he obtained and which he illustrated under the name of "Kraftwirkungsfiguren" in a recent issue of *Stahl und Eisen* (vol. 41, pages 1193 to 1197) are very curious. By the courtesy of Dr. Fry we are able to reproduce photographs of some of these peculiar strain figures; they are all in natural size, unless otherwise stated, and we had best begin by describing our illustrations.

Fig. 1 is a photograph of a mild steel specimen

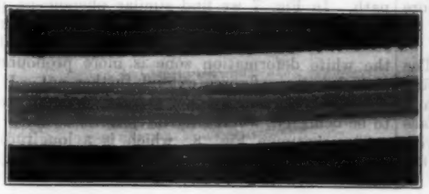


FIG. 1.

FIG. 2.

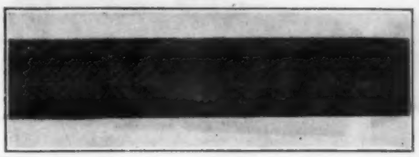


FIG. 3a.

FIG. 3b.

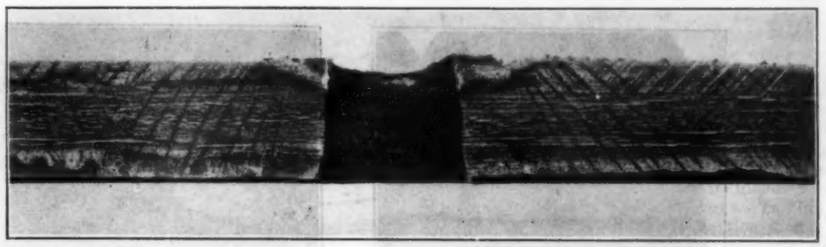


FIG. 4.

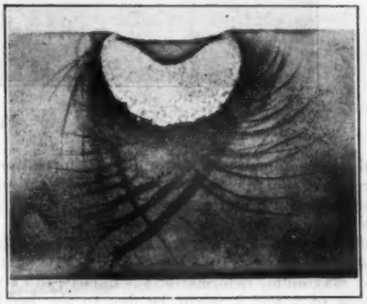


FIG. 5.

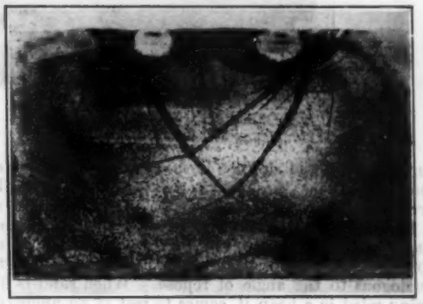
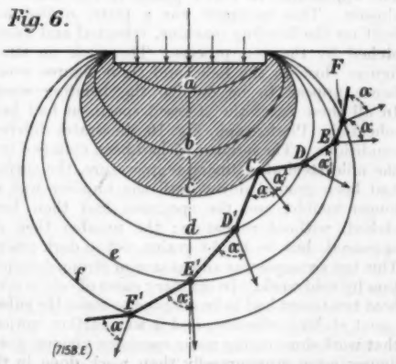


FIG. 7.

Fig. 6.



etched in the usual way with the copper-ammonium chloride solution of Heyn; the parallel dark stripes mark the segregation of phosphorus compounds. Figs. 2 and 3 show the same specimen etched by the modified new method. In Fig. 2 we notice two systems of dark stripes, intersecting nearly at right angles and partly overlapping the original stripes. The three figures 3A, 3B, 3C, again refer to the same specimen; 3A is a longitudinal section, 3B a cross section, and 3C a horizontal section made about 2 mm. below the surface of the sheet metal. In these cases the etching was maintained for a few minutes. The specimen of Fig. 4 was kept in the new bath for 10 hours or more, and the etching had penetrated to greater depth, whilst some of the fine detail of the figures was lost. In preparing these specimens, Dr. Fry heated the sheet first for half an hour or so up to 200 deg. C., the specimen was then cut with the saw, plane, or file, and ground and polished.

The reagent is a strongly acid solution of copper chloride, containing so much acid that metallic

copper is not deposited upon the iron; the deposit formed consists, according to Gmelin-Kraut, of a dark copper hydride which reacts with the iron under formation of iron hydride. Further information about this point would be desirable. When a microscopic section is to be prepared the bath consists of crystallised copper chloride, 5 grammes, and the following liquids in cubic centimetres: Concentrated hydrochloric acid, 40, alcohol 25, water 30. When the examination is to be macroscopic as in the cases so far mentioned, a more concentrated solution is used; it contains 90 grammes of copper chloride in 120 cub. cm. of hydrochloric acid and 100 cub. cm. of water. The etching may have to be repeated by rubbing powdered copper chloride on the surface with a cloth dipped into the solution. Finally the surface is gently dried and washed with alcohol (not with water). When the contrasts are not distinct, the punch is surrounded by a white zone of maximum deformation; outside this we notice a system of dark, peculiarly curved strain figures, penetrating deep into the iron. The zone of greatest deformation is indicated in Fig. 6 by the curves *a*, *b*, *c*; outside *c* we notice the gliding lines which, as Fig. 6 shows, meet the successive deformation curves *c*, *d*, *e*, *f*, at the points F, E, D, C, D′, E′, F′, always at the same angle *a*. The gliding lines thus seemed to have been deflected continuously from a straight path. In Fig. 7 we find similar phenomena produced by a hollow punch driven into a block of steel. In this case the dark zone surrounding the white deformation zone is more pronounced, and the strain figures extend further out. It is, moreover, noteworthy that the strain figures seem to be deflected, where they intersect.

The specimen Fig. 8, which is a longitudinal section, was bent at a temperature of 200 deg. C, into the temperature ranges of solid solution. Thus heating up to 600 deg. C. sometimes made the figures indistinct, whilst under other conditions temperatures of 730 deg. brought the phenomenon out well.

Dr. Fry discusses the possible causes of these peculiar phenomena with the aid of many other fine micro-photographs, of which we only reproduce one, Fig. 11, because it illustrates a point already mentioned. We see in this photograph indications of an arrangement of the particles, especially in the dark portions, at definite angles to the direction of the stress. When crystalline metals or substances are put under stress, the individual grains may either split right across or the aggregates of the structure may be loosened, interstices being formed between the grains, or the grains may be crushed in such a way that only a very strong magnification would disclose any distinct detail. The order in which these three effects have been stated is not

Fig. 8. Fig. 9.

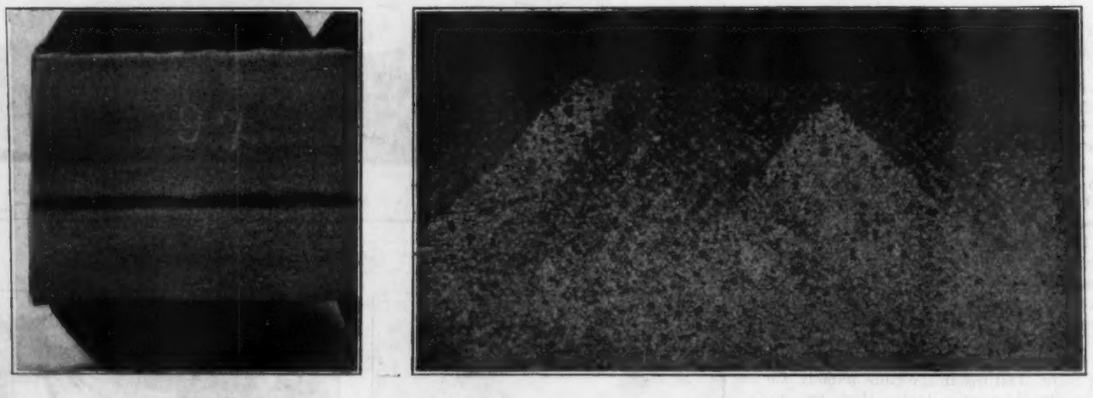


Fig. 10. Fig. 11.

surface is ground down. It is assumed that the reagent darkens those parts most rapidly which are most reactive.

In explanation of the peculiar patterns Dr. Fry suggests that the lines represent surfaces of discontinuity or gliding and fracture cones somewhat analogous to the angle of repose. When sand is being piled in a heap it comes to rest at an angle with the direction of the force of gravity which depends upon the friction between the sand grains. When crystals are crushed or a punch is forced into a material the resulting gliding surface will also form a definite angle with the direction of the stress. Such fracture cones were observed in steel, *e.g.*, by E. H. Schulz and J. Goebel (see *Stahl und Eisen* of November 4, 1920) when studying the so-called woody-fibre structure of steel. Driving cylindrical punches into cylindrical blocks of a steel which was disseminated with slag enclosures, they found that surfaces of discontinuity developed under the punch sometimes to such an extent that a cone actually would break out when the cup formed by the punching was crushed. The photographs, Figs. 2 to 4, suggest such surfaces of discontinuity. More striking still are the photographs, Figs. 5 and 7 and the diagram Fig. 6, which is to explain Fig. 5. The first photograph, Fig. 5, is a longitudinal section through a block of soft iron through which a punch has been forced at ordinary temperature; the section was heated to 730 deg. C. for 6 hours, and then etched as described. The hole formed by the and then etched. The strongest deformation is here in the middle portion; there both the parts under tension and those under compression have exerted a pressure upon the interior, and the gliding lines coalesce. Figs. 5, 7, 8, further suggest that the peculiar strain figures arise in parts of lesser (not maximum) deformation; similarly the strain figures of 2 and 3 might be due to the bending which the sheet had undergone when being rolled. The appearance of Fig. 9 points to the same conclusion. This specimen was a plate, drilled and bent on the bending machine, reheated and finally etched by the new process. There are no strain figures close to the hole, and these figures would hence appear to be due to the bending stress. In all these cases the stressed specimen had been reheated. Photograph, Fig. 10, illustrates different conditions. The number 97 had been stamped into the mild steel at ordinary temperature, the surface had been ground down until the number was no longer visible, and the specimen had then been etched, without reheating; the number then reappeared, but in bright grains, not in dark grains. This last example was an instance of strong deformation by cold work. In ordinary cases of cold work a heat treatment had to be adopted to make the subsequent etching effective, and it was further noticed that work done on the warm specimen yielded strain figures more pronouncedly than work done in the cold. On the other hand, the strain figures could be made to vanish again when the heating was carried that of increasing stress; in fact, some of the specimens of Dr. Fry, broken in impact tests, show the first-mentioned effect most distinctly near the fracture. Now in the new etching, as in other etching processes, certain parts turn dark. Dr. Fry argues that the darkening of Fig. 11 and of other cases is compatible with the third kind of disintegration of the structure, and that the linear arrangement marks, not directions of splitting, but directions of gliding. He admits that he is not able fully to explain his observations and that the interpretation of his strain figures calls for considerable caution.

So far he has only obtained the peculiar results with mild steel, particularly after applying stress, and not in all mild steels with the same distinctness. Etching alone, following cold work, is not sufficient to bring out the strain figures, as we stated already. A reheating has to follow, and it would therefore appear that the strain figures are not the direct primary effects of plastic or elastic deformation, but secondary phenomena which the thermal treatment develops as a consequence of the strains left in the metal. Hence the strain figures cannot be directly utilised as tests of the quality of the material. But the interpretation of the results of our ordinary strength tests and the co-ordination of various tests is generally a controversial matter, and Dr. Fry's method is certainly to be welcomed as a new means of investigation, as it reveals unexpected effects of long-practised methods under peculiar conditions

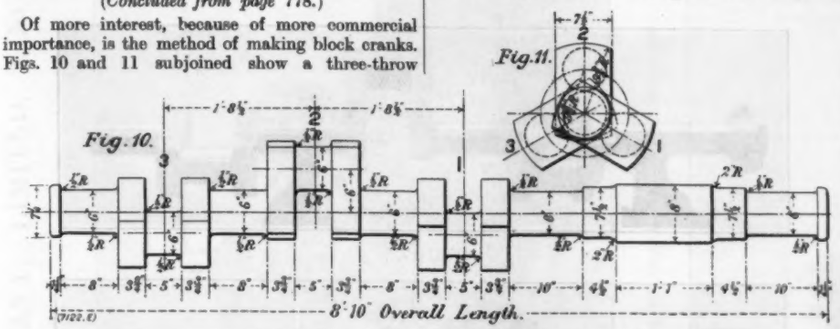
which he will continue to study, we hope. Dr. Fry points to one parallel between his observations and what is known as a "blue brittleness." Both his strain figures and blue brittleness are observed when the specimen has either been stressed near 200 deg. C. or has been heated to that temperature after cold work.

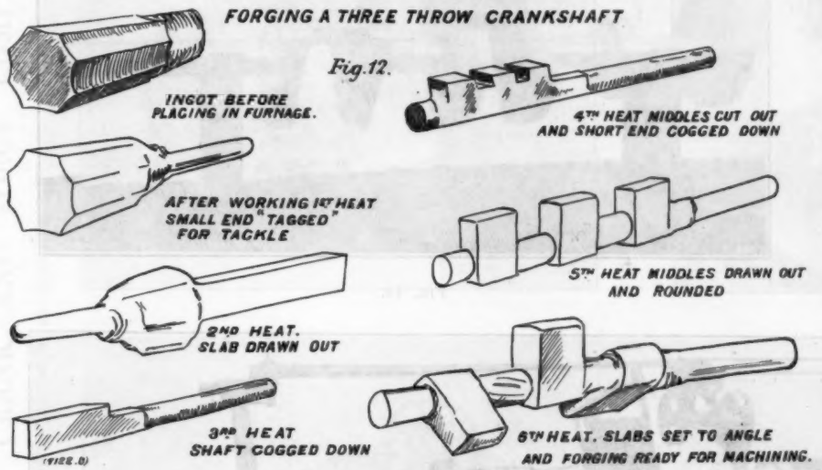
THE MANUFACTURE OF CRANKSHAFTS.

(Concluded from page 778.)

Of more interest, because of more commercial importance, is the method of making block cranks. Figs. 10 and 11 subjoined show a three-throw crankshaft for a pump, and Fig. 12 illustrates the various stages in manufacture from the ingot to the final forging ready for the machine shop. The steel ingot is placed with its smaller end in the furnace and left there until that end is hot enough to forge. The outer end projects from the furnace, the wall of the latter being loosely built up round the body of the ingot to conserve the heat. When the end is hot enough the wall is pulled down and the ingot taken to the press by the crane which serves the latter. The ingot is handled by a porter-bar cramped to the cold end, this bar being weighted so that the load is in balance. The first press operation is to tag down the end of the ingot, so as to form an extension to which the porter-bar can remain fixed during subsequent operations.

The ingot is now returned to the furnace and heated at the other end, the furnace wall being temporarily rebuilt around it as before. After the second heat it is drawn down under the press into a rectangular slab. At the third heat the end of the slab is worked down to the forging size of the shaft and the slab is cut off the ingot. After the next heat pieces are cut out of the slab so as to leave the crank blocks in rudimentary form, and after another heat the shaft is drawn out and rounded up between the blocks, the slab being manipulated by means of an electric turning gear operated from the cage of the overhead crane. The forging would then be finished, were it desired to make a shaft with the three throws in line with each other. The usual requirement, however, is for a shaft having the cranks at 120 deg., and to procure this result the shaft has to be twisted. To twist the shaft it is first heated and then held in the press by one of the crank-blocks. A large wrench is then slipped over the adjacent crank-block and the handle of the wrench is slowly lifted by the overhead crane. The wrench is reversed after all the twist that can be given with it in its first position has been effected, and the whole shaft is reversed in the press, or held by another block as required. The requisite amount of twisting into correct angle is checked by special angle gauges. Of course, after being forged and twisted, every shaft undergoes a thorough annealing before leaving the forge.

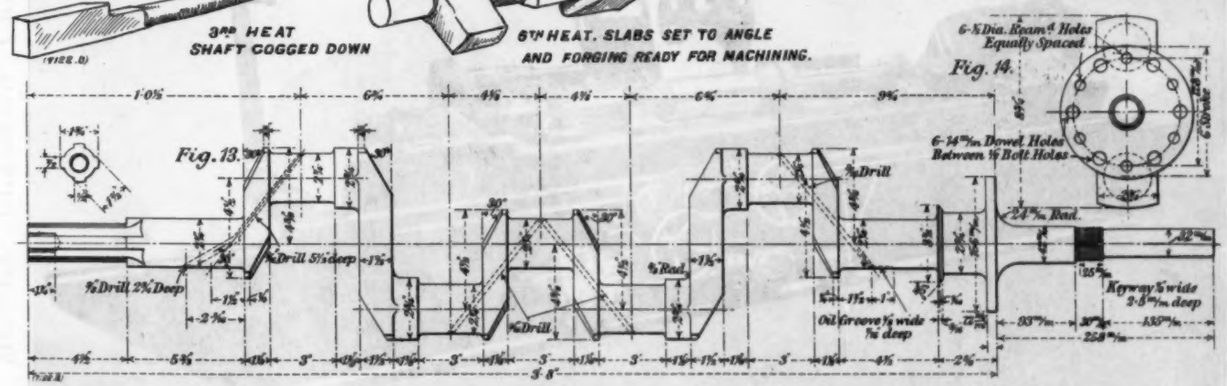


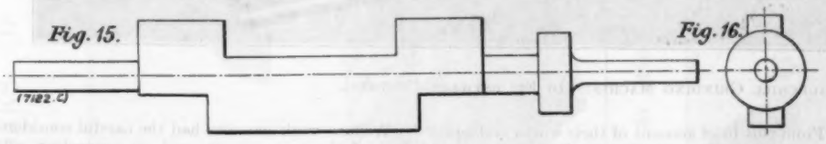

FORGING A THREE THROW CRANKSHAFT
Fig. 12.
INGOT BEFORE PLACING IN FURNACE.
4TH HEAT MIDDLES CUT OUT AND SHORT END COGGED DOWN
AFTER WORKING 1ST HEAT SMALL END "TAGGED" FOR TACKLE
5TH HEAT MIDDLES DRAWN OUT AND ROUNDED
2ND HEAT. SLAB DRAWN OUT
3RD HEAT SHAFT COGGED DOWN
6TH HEAT. SLABS SET TO ANGLE AND FORGING READY FOR MACHINING.

The drawing of the shaft is completed by the addition of the crank webs and pins, and the shaft is then annealed. The forging for the crankshaft of a motor lorry is shown in Figs. 15 and 16, the finished product of the machine shops, corresponding to the forging, being illustrated in Figs. 13 and 14. Messrs. Clarke's Crank and Forge Company, Limited, make large numbers of shafts of this kind. Naturally, where large numbers of these can be put through at once they would be made more cheaply as stampings. The four throws being, of course, all in the same plane, there is no twisting to be done in this case, and the forging is comparatively simple.

Figs. 17 and 18 show a three-throw and a two-throw crankshaft, the former for a triple-expansion marine engine and the latter for a road locomotive. The range of cranks turned out by Messrs. Clarke's Crank and Forge Company is far too great to deal with in the space at our disposal, and the illustrations we have given must suffice. Crankshafts of all kinds and sizes, whether bent, forged from the solid, or built up, come within their field of operations, these shafts being supplied either as forgings, rough machined, or finished and ground to the finest limits, complete with keyways, &c., ready for use. In the illustration of the machine shops on Plate XLIII, published with our last issue, some of the work going through can be seen in various stages of manufacture.

The equipment of the machine shops comprises many interesting machine tools. The whole of the machinery is electrically driven, and each bay is served by an overhead electric crane. The heavier machine tools are driven by their own electric motors, one of such machines being a lathe capable of swinging 72 in. diameter over the saddle and taking work up to 24 ft. long between centres. Another lathe will swing work 60 in. diameter over the saddle and 16 ft. between centres. Turning to the more specialised machines, mention should be made of the Muir puncher-slotting machines, used for cutting out the spaces between the crank webs before the pins are turned. In the case of a large crank a very considerable lump of solid metal has to be cut out, and the old practice, of course, was to drill a line of holes across the block between the webs and to make a narrow cut along the inside of each web to meet the line of holes, by means of a slotting machine or a cold saw, so that the interior lump of the block could be bodily removed. Such a method was exceedingly tedious, and it required the use of two machines with all the fixing, unfixing, transportation, &c., involved.





The puncher-slotters built by Messrs. Wm. Muir and Co., Limited, of Manchester, and used at the works with which we are dealing, work directly on the solid undrilled forgings and cut out the gaps in hardly more time than would be required for drilling the holes required in the old method. A photograph of one of these machines is reproduced in Fig. 20, page 813. The internal mechanism consists of gears running in oil, combined with a

slotted link of forged and hardened steel, while the ram is a solid casting having T-slots on its front surface, to which any desired kind of tool may be bolted. For gapping cranks a tool holder of the snout form, as shown in the photograph, is employed. The head and the bed are in one casting, and all slides are square, the whole design being of immense strength and rigidity. That such features are wanted will be understood by the fact that the machine will cut out a gap 4 in. wide and 6 in. long through a 6 in. block in 16 minutes. Under ordinary workshop conditions one of these machines will remove 30-ton steel at the rate of 18 cub. in. per minute.

The cranks having been slotted, the next operation is to turn the pins. In the case of large cranks this is done on lathes in the usual manner, but for cranks of moderate dimensions crankpin turning machines constructed by Messrs. Gardner and Co., Limited, of Patricroft, Manchester, are used. The general appearance of such a machine is shown in Fig. 21, page 813, while more detailed views are given in Figs. 22 and 23. The headstock carries a hollow spindle large enough to permit any crankshaft within the capacity of the machine to be threaded through it. A chuck to suit the required throw is mounted on the end of the spindle, and this grips one of the crank webs next to the pin to be turned. The part of the shaft inside the spindle is carried by a steady, and the other end is supported by a tailstock. The tool slide is very massive and carries two tool posts, that at the front holding the roughing tool and the one at the back the finishing tool. The special feature of the machine is that the full width of a crankpin is formed at one cut, this being possible on account of the great rigidity with which the work is held. Forming the crankpins in this manner avoids the necessity for any longitudinal traverse, thus greatly simplifying the operation of the machine and enhancing the rigidity of its design. As an example of the speed of the machine it may be mentioned that a crank for an engine of 11 in. stroke, having a pin 2⅞ in. diameter by 3 in. long, can be finished on a Gardner machine in 18 minutes cutting time. The crank starts with the block roughly gapped out in the usual manner, and the work includes machining up the inside faces of the webs to size, forming the crankpin and rounding off the outer ends of the webs. The pin is left 0·040 in. over size for grinding in the case of the smaller types, but pins are frequently finished to actual size on the Gardiner machine in the case of the larger crankshafts.

For grinding crankshafts or other products of their works to size, Messrs. Clarke's Crank and Forge Company have several grinding machines, the largest of which was supplied by Messrs. Chas. Churchill and Co., Limited, of Manchester. This is of the type illustrated in Fig. 19, subjoined. It is fitted with raised heads in order to accommodate work of 30 in. diameter, and will take work up to 16 ft. long between centres. The grinding wheel is 40 in. diameter. The wheel has two speeds, the work has eight speeds, and there are sixteen speeds of the table. For crankshaft work a special pair of throw-blocks is provided, capable of swinging crankshafts up to 8 in. diameter and up to 4 tons in weight.

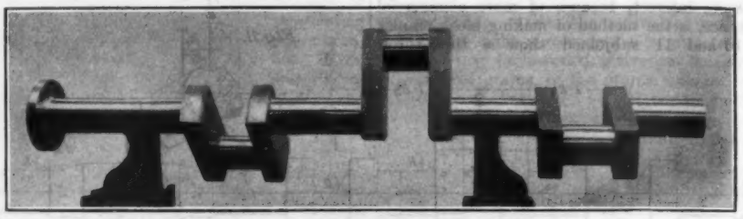


Fig. 17.

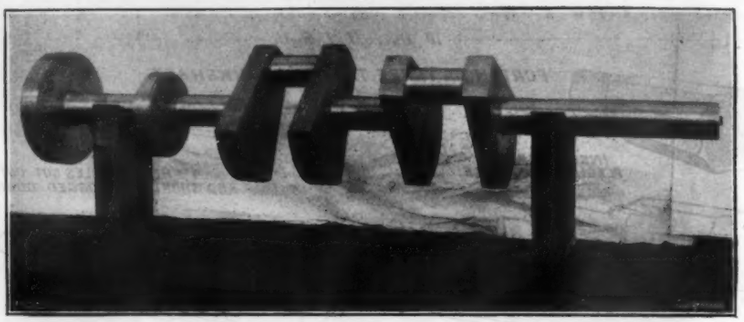


Fig. 18.

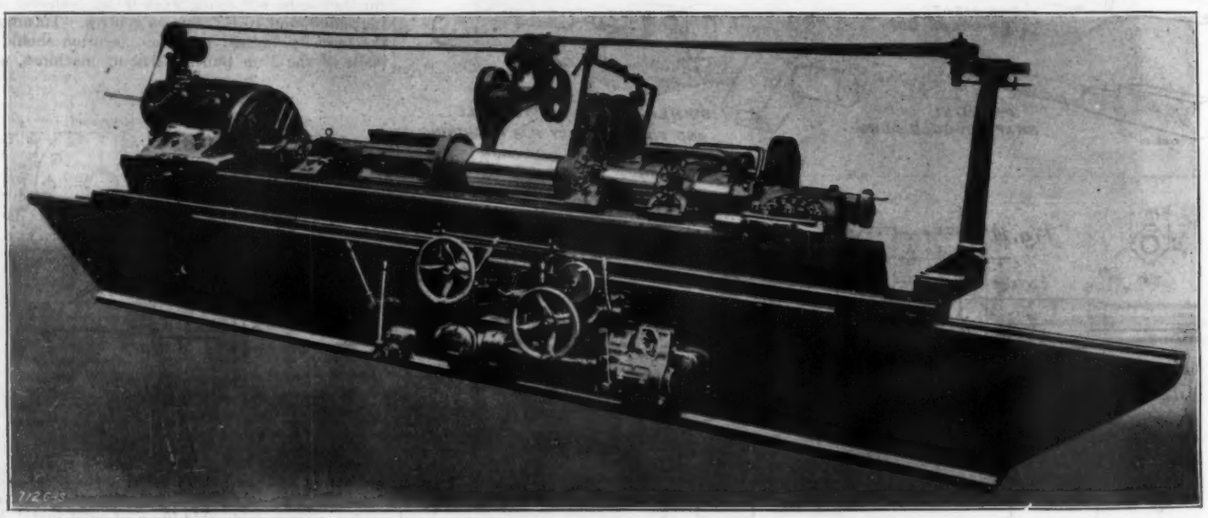


Fig. 19. Churchill Grinding Machine (16 Ft. between Centres).

From this brief account of their works and equipment it will be seen that Messrs. Clarke's Crank and Forge Company, Limited, have all the necessary facilities for the production of crankshafts of every type, either in the completely finished state, or rough-machined, or as forgings only. The long experience of the firm in this particular class of work, and their concentration upon crankshaft manufacture as a speciality, have naturally enabled them to reach a degree of efficiency which could not be expected in a works where crankshaft making is only an occasional job. The traditions of the firm, assisted by a rigid system of inspection and testing, ensure the maintenance of a high standard of workmanship, while the system of payment by results promotes the efficiency of labour. A large percentage of the company's forgings are made under the inspection of the British and other Admiralties, Lloyds, the Bureau Veritas, &c. Great attention is paid to the testing of material used in the manufacture of forgings, a 30-ton Buckton testing machine, Brinell and other apparatus being constantly in use. It is scarcely necessary to add that equal care is taken in carrying out heat treatment processes under scientific control.

Welfare work has also had the careful consideration of the management, and, in connection with this matter, a large hall provides facilities for indoor games and recreations, besides containing dressing rooms and lavatories for the members of the football and cricket clubs.

Cost of Living in Sweden.—The calculations as to the changes in the cost of living in Sweden conducted by the Labour Board at the beginning of every quarter have been concluded for the period ending with the close of the third quarter in 1921, says *Swedish Export*. According to these calculations the general rise in the cost of living from July, 1914, is 131 per cent., the index figure being therefore 231. At the close of the preceding quarter the corresponding figure was 236, thus showing a reduction of 5 units or about 2 per cent.

THE WORKS OF MESSRS. CLARKE'S CRANK AND FORGE COMPANY, LIMITED, LINCOLN.

(*For Description, see opposite page.*)

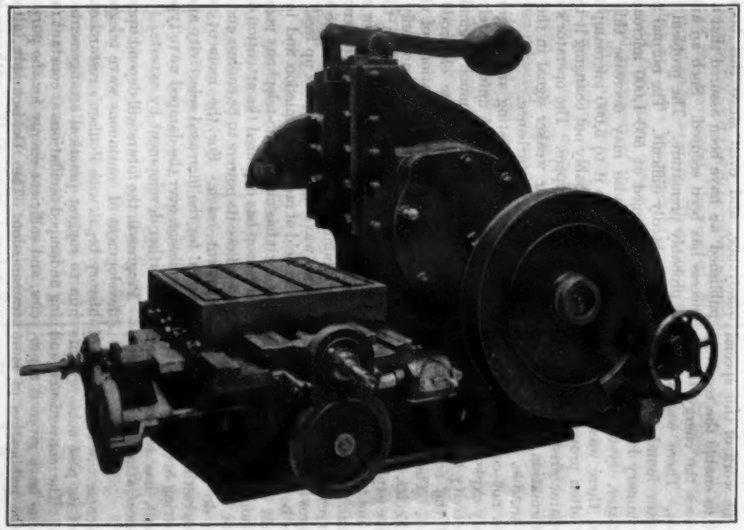


FIG. 20. MUIR'S PUNCHER-SLOTTING MACHINE.

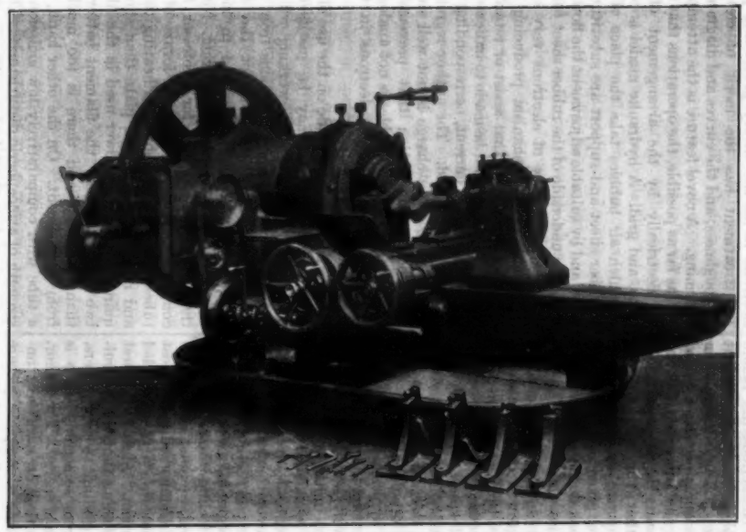


FIG. 21. GARDNER CRANKPIN TURNING MACHINE.

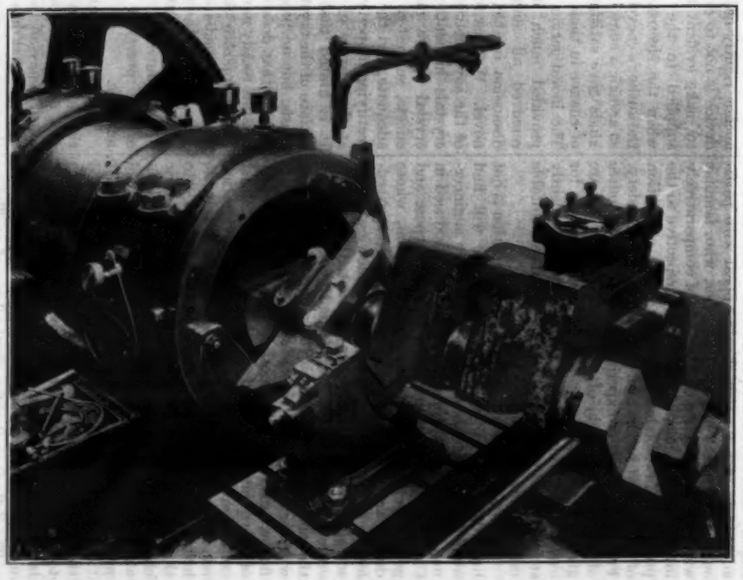


FIG. 22. HEAD OF CRANKPIN TURNING MACHINE.

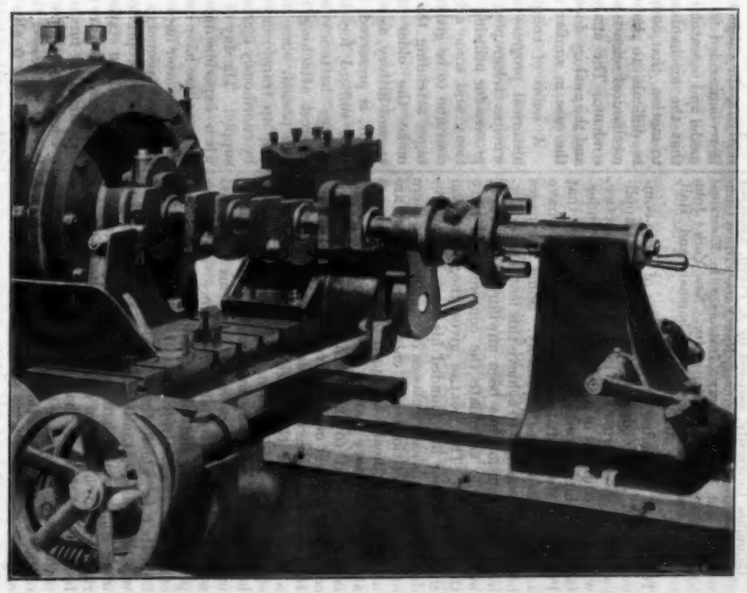


FIG. 23. FOUR-THROW CRANKSHAFT BEING MACHINED.

LITERATURE.

Principles of Radio-Communication. By J. H. Morecroft, Associate Professor of Electrical Engineering, Columbia University, assisted by A. Pinto, Assistant to Chief Electrical Engineer, New York Edison Company, and W. A. Curry, Instructor in Electrical Engineering, Columbia University. New York: John Wiley and Sons. London: Chapman and Hall, Limited. [Price 45*s.* net.]

To attempt to discuss the principles of radio-communication and to describe the mechanical applications of those principles in commercial practice, within the compass of a single volume, is to undertake an ambitious task, but it will be admitted that Professor Morecroft and his coadjutors have acquitted themselves creditably. Some 900 pages have been necessary to achieve this feat, and doubtless much excision has been unwillingly practised, but those who assimilate the contents will have their reward. The treatise gives the impression that the author has founded his work on lectures delivered to successive classes of students, for there are more repetitions and enlargements than are usual in methodically arranged text-books, but are almost a necessary feature in class teaching. This is not intended to imply that these repetitions constitute a defect or a disadvantage to the student. Indeed, they enable the reader or student to obtain a wider view of the bearing and importance of statements, which could not be adequately apprehended when originally introduced. For example, in the early chapters many problems connected with resistance, coupling, resonance and other phenomena are introduced and explained, but cannot be exhaustively treated, nor the directions indicated in which these fundamental principles will be applied. Limitations or extensions may be more conveniently handled later, and the author rightly avails himself of repetitions, if they make for lucidity. A feature that may be mentioned here is the very effective use made of oscillograms. Many of these are reproductions from those obtained in original researches, and by their use the student, who is ploughing his way through the preliminary theory, is brought one step nearer to actual practice and gains a closer insight into the methods of enquiry than mere description affords. The methods adopted in investigation should appeal with particular force to the electrical engineer, who, familiar with dynamo practice and the use of comparatively low frequencies, has to adjust his perspective to the problems of radiotelegraphy, and to the estimation of effects that he has hitherto neglected with safety. From the details of experiments made in the course of practical research, of which many examples are given, he will learn to select the critical points for examination, the variables that can be conveniently studied, and the adoption of the most suitable methods for conducting an enquiry.

Necessarily, much of the earlier explanation is not limited solely to radiotelegraphy, but will find numerous applications in general electric engineering. The subject properly so called is introduced in Chapter III, wherein is sketched the purpose and general scheme of wireless communication, whose details are amplified in the following pages. Needless to say, that the author accepts the view of the so-called electronic theory, or that the electric current is logically and consistently explained by the motion of electrons. It is not equally clear whether the discredited ether is dismissed as superfluous, or is retained in another form. In the theory of wave propagation, it is necessary, or at least convenient, to imagine a medium in which vibration can take place, and to supply this medium, the rôle hitherto assigned to the ether, recourse is had "to the superimposed electric fields of all the electric charges in the universe." The student will probably find this a hard sentence to grasp, and he will probably prefer the form later used, asserting that "the electric magnetic waves are propagated through the ether with a velocity corresponding to that of light." There may be as much difficulty latent in these words, but it is concealed by the use of a familiar phrase.

The following chapter on the laws of oscillating currents forms a fitting introduction to the description of the mechanism of the spark gap and other devices: a theme that we imagine will occupy less attention in future treatises. The investigation of the discharge of a condenser in a single circuit, however, facilitates the explanation of many phenomena of a more complicated character in coupled circuits, and cannot be overlooked. Before studying the subject of coupled circuits the student is recommended to construct a coupled pendulum model and to watch its behaviour, since it is asserted that the mechanism offers the same peculiarities to motion, that coupled circuits do to current. It is difficult to know whether these appeals to mechanical science afford any real assistance to the student. The analysis here given is exhaustive, and the analogy does not break down, as is too often the case in similar illustrations.

A sense of completeness and the sequence of historical progress in the growth of long-distance wireless telegraphy, require the description of a process for utilising high-frequency damped oscillations, and some account of spark telegraphy will continue to be given in text-books, but the advantages attending the use of continuous waves will make the older method obsolete. Some very ancient history, as reckoned by progressive development, is preserved, in presenting the arrangements that sufficed for direct excitation by means of storage batteries and the induction coil. The interest attaching to such elementary appliances has passed, since the advent of alternators and step-up transformers has revolutionised procedure by enormously increasing the potential of the energy supply. The day of small beginnings was necessary when experimenters were feeling their way, but just as these have disappeared, we must be prepared to see the later improvements, embodied in the most cherished specimens of engineering art, superseded by more appropriate mechanism. Already the best equipped land stations are feeling that the difficulties of insulation are imposing a limit to their powers, and that for further progress something more is needed than a simple increase of energy. The author, having witnessed the evolution of successive improvements, is able to provide a complete picture of the growth of both the theory and the industry.

The evolution is most distinctly marked in the changes of popularity that have overtaken the various forms of detector—a term to which the author rightly objects, for the work of this special device is not to detect, but to enable the receivers to make evident to the senses the energy that is supplied to the telephones. There was a time when the electrolytic detector found favour, but the author's encyclopædic summary does not include so archaic a contrivance. Later, crystals of various kinds gave satisfaction, but there was an element of chance in their use that often proved annoying. The investigation of the characteristic curves has provided much useful information, but has not removed all sources of trouble. The author's discussion is able, but does not contain anything novel. We look to see if any explanation is offered of the asymmetrical conductivity of two dissimilar crystals in contact, or of the combination of a crystal with a metal point. The thermo-electric effects, suggested by Dr. Eccles, are not thought adequate, and the alternative explanation, that the rectifying property may be due to electrolytic action at the surface of the crystal, is also unsatisfying. It is hinted that electron evaporation from the surface of the crystal may provide a plausible hypothesis, but no proposal can be considered as satisfactory that does not explain the fact, that certain crystals rectify in one direction for low voltages, and in the opposite direction for high voltages, and at some intermediate voltage do not rectify at all. Theoretically, the point is interesting, but the advent of the vacuum tube, permitting accurate and definitely controlled adjustment, has removed much of the practical importance attaching to such minutiæ.

The vacuum tube has become the instrument of the hour, both by reason of its past achievements and its future possibilities. The convenience and sensitiveness of the apparatus have given it a prominence that has led to the publication of more than one monograph, with which Professor Morecroft's general work has to compete. The theory has been elaborated by various hands, but we cannot say that it has grown simpler in the process. The manipulation is better understood than the principles on which the operation depends. The author follows the general lines, tracing the successive improvements through the two, to the three, electrode form, the theory proceeding *pari passu*. The treatment has the merit of clearness and thoroughness, and the curves and diagrams are very informing. A novel feature is the attempt to visualise, as far as possible, the operations that are carried on electrically by the arrangement of filament, plate, and grid. A hydraulic model is constructed in which air bubbles take the place of electrons, a rubber sheet and support are substituted for the plate, and by suitable adjustment the flow of bubbles along the underside of the rubber sheet can be made to imitate the flow of electrons very closely. A small additional mechanism producing differences of level in the sheet, that assist or retard the passage of air bubbles, can be made to indicate the variations in the plate current, corresponding to a negative or positive grid. The author regrets that the effect of the space charge is not well simulated in the model. The action that prevents the free movement of the air bubbles is not analogous to the mutual repulsion of the electrons in the actual space charge effect.

Some criticisms are made on the use of the triode as a detector, which may be justified, but the necessities of commercial working will introduce conditions that compel deviations from theoretical conclusions, and that have not the support of laboratory experiments, designed to indicate the most economical methods of working. Nevertheless, there are good grounds for Professor Morecroft's contention, that the present forms of detecting tubes use too much power in heating the filament, and more voltage in the plate than should be required. Excessive power used in the filament has two disadvantages: the filament battery is larger than necessary, and there is too much emission from the filament. On the other hand, the use of a tube with comparatively low emission limits the strength of atmospheric disturbances. These erratic noises heard in the telephone, the operators' bugbear, place a decided limit on the effective radius of transmission. Experiments and investigations are being carried on with the view of reducing the annoyance, and even since this book has been published we have been assured that a sensational success has been secured. Such an announcement is probably premature. The problem to be solved is undoubtedly difficult. The normal plate current may be assumed at 500–1,000 microamperes: the atmospheric pulse may decrease this current to zero, or increase it to 5,000 microamperes, whereas the signal is probably not changing it by more than a single microampere. The operator's ear becomes insensitive to the weaker signal in the presence of such abnormal disturbance.

Much that is interesting and suggestive cannot even be mentioned, and unfortunately, the omissions include the results of much original work. The detailed study of the three electrode tube as a converter and the determinations of efficiency are subjects that call for remark, not only on account of the practical results obtained in the one case, but the discussion well illustrates how a tube functions. The problem of relative efficiency is treated very illuminatingly and deserves close study. Continuous wave telegraphy opens up fresh possibilities in the field of radio transmission and invites quotation, for it has made radio-telephony possible, and for this reason has captured the attention of the public, who believe its powers to be endless and within their impatient reach. For the moment we must be grateful for the increased selectivity and efficacy of transmission over the damped wave type, and await the further development by experts.

Progress in the future will depend upon the further development of continuous wave telegraphy, whose history began with Poulsen's researches. These led him to suggest practical arrangements for producing undamped oscillations at constant radio frequencies, and sufficient energy for the purposes of radio transmission. The Goldschmidt alternator and other forms, in connection with specially devised apparatus, will give like results, but to Poulsen is due the merit of commercial success, and we are glad to find that justice is done to this early pioneer.

Both the Goldschmidt and the Alexanderson alternator come under review, and the different principles involved in each is very properly emphasised. These alternators provide at their terminals an e.m.f. of frequency sufficiently high to be used directly for radio transmission, but, requiring the highest type of engineering skill in their construction become prohibitive on the score of expense. The author favours the production of alternators of lower frequency, as easier to build, cheaper in construction and giving equal reliability of operation. Such instruments, in connection with a frequency changer or transformer to step up the frequency to the desired value, are likely to come into demand. Some forms of static changers are described, and also other forms depending on the utilization of a rectifying element in the primary circuit. The methods of signalling and reception necessarily receive attention, and special methods are considered in connection with radiotelephony.

Being in possession of sources of power which will produce undamped high-frequency currents, the radio transmission of speech naturally follows. The plans for effecting the necessary modulation are discussed with great care, especially the Heising system, which is preferred. Of more popular interest, however, is a scheme of "double modulation" to enable several radiophone conversations to be carried on without mutual interruption, on the same high-frequency carrier wave, in an area of congested communication. Another considerable advance is foreshadowed in the possibility of simultaneous transmission and reception. The progress of telephony has been retarded by the difficulty of changing easily from the operation of receiving to that of transmitting, but this drawback has been overcome by using two antennæ, well separated from each other, and using one only for transmission, reserving the other for receiving. By such an arrangement, each operator can talk and listen at the same time as in ordinary wire telephony. Of course, provision has to be made to prevent the e.m.f., induced in the receiving antenna by the local transmitting antenna, interfering with the original e.m.f. from the distant transmitter.

The chapter on antennæ and radiation, or at least some portions of it, might have been given earlier with advantage, and similarly the reader would have been assisted if the description of such instruments as the wavemeter, decremeter, &c., had been offered at an earlier stage. These chapters, inserted as they are, have the effect of separating the discussion of the triode, used as an amplifier, from the general treatment of the three electrode vacuum tube. This arrangement of the chapters is, however, a small defect, if it be a defect at all, and is certainly of small moment in comparison with the great store of valuable information that the author has collected and made available. The progress of electrical and mechanical science will soon render some portions of the book obsolescent, but the mathematical analysis elucidating the general theory will long retain its value.

Hints to Travellers · Scientific and General. Tenth edition, revised and corrected from the ninth edition. Edited for the Council of the Royal Geographical Society by E. A. REEVES, F.R.A.S., F.R.G.S. Vol. I. *Surveying and Practical Astronomy.* Vol. II. *Meteorology, Photography, Geology, Natural History, Anthropology, Industry and Commerce, Archæology, Medical, &c.* London: Royal Geographical Society. [Price 21*s.* net.]

FIFTEEN years have passed since the last edition of this useful handbook was prepared, and considerable enlargement of the contents has been found to be necessary, due mainly to the severe requirements of scientific geography. The days are past when a traveller could enjoy a reputation as an explorer, if he brought home some rough notes of a journey through an uncharted country, based on rough prismatic compass route mapping. Such inexact surveys were of little worth, even when information concerning the earth's surface was less precise than at present, and now they may be said to possess no cartalogical value. Moreover, the opportunities of applying such rough route mapping schemes are growing less. Rigorous surveys have pushed their way into unoccupied country, and an explorer can generally rely upon finding well determined fixed points on which to base his surveys and to extend approximately the same accuracy to unsurveyed regions.

In the work under notice the contributer of the section "On Surveying and Astronomical Observations," Mr. E. A. Reeves, has foreseen the possibility that the explorer may find himself deprived of the assistance of fixed points, and consequently he will have to adopt astronomical methods for fixing fiducial stations and may find it necessary to measure a base line. The former provides a very necessary training; we should doubt, however, if the elaborate explanations of deducing corrections for all the possible errors that may occur in the case of a Jäderin tape, such as errors of division, temperature effects, inclination, sag, &c., will be used, and probably the author himself entertains some doubt, for though many numerical corrections are carefully worked out, apparently there is no mention of any mechanical contrivance for maintaining uniformity of strain on the tape or wire. Of course, there will be many admirably equipped expeditions, in which all the artifices that experience can suggest or ingenuity furnish, will be pressed into service, but to those who use such apparatus this book is not addressed.

The effort to enforce the need for greater accuracy is, of course, most praiseworthy, but within a small compass there is hardly room to cater for both the trained observer and the inexperienced amateur. The plane table with its accessories seems to us the instrument, *par excellence*, for those to whom this manual is likely to appeal. One can heartily endorse Mr. Reeves' remark, that the plane table deserves to be more generally used than it has been, as even for traversing, it gives better results than the prismatic compass. We are not so sure that we agree with him in the assertion that photographic surveying can never supersede the work of the plane table. Where the main control for a photographic survey is based on a trigonometrical origin, and the co-ordinates of the triangulation points have been determined with the requisite degree of accuracy, the method can be regarded as a valuable adjunct to instrumental topographic methods. The author points out quite rightly, that it is not enough for a surveyor to be able to fix points, he should be able to give a correct representation to the characteristic features of the country, and this latter work, in which it is admitted the surveyor often fails, is admirably performed by the photographic camera.

The description of a suitable scientific outfit is admirable. Accumulated experience has decided the selection of what is necessary, and has indicated the methods of packing and carriage that will reduce the sources of annoyances to a minimum. That nicety of fit on which an instrument-maker prides himself, and by which he may reduce bulk by a few cubic inches, can give infinite trouble to the observer, who has to pack and unpack in insufficient light or even in the dark. Bulk rarely presents any difficulty to the traveller, weight has great drawbacks. Many and useful are the hints given, and few, we imagine, would neglect the invitation to make enquiry at the rooms of the Royal Geographical Society concerning the kind of packing best suited for special purposes and fields of exploration.

The description of instruments follows the usual lines, the rules for practice being very plainly expressed, but it may be questioned if the most is made of the advantages offered by the tacheometer. The references to the theory and use of this instrument are rather ancient, and various improvements have been introduced in the construction since 1891, the date to which we are referred for the particulars supplied to the Society by Colonel Tanner. Since it is an instrument that is gaining in popularity, a fuller description of its capacities and its weaknesses might have been anticipated. The section ends with the derivation of some formulæ, plane and spherical, and some valuable remarks on map projection, which might have been usefully extended.

The next and longest section of the book is devoted to geographical survey and mapping. The author sets out very distinctly the method of charting and the standard of accuracy that is within the reach of unprofessional aid. "It is a mistake to suppose that because a large trigonometrical survey of a country cannot be undertaken, nothing can be done but rough prismatic compass route mapping: for it is possible to produce a really good topographical map, based on rapid triangulation and filled in by plane tabling—so accurate ought it to be, that drawn on the 1 : 250,000 scale, the error in the position of any of the fixed points on the map should be inappreciable to the eye." These are cheerful words and should give the amateur hope and courage. The section that will give the greatest satisfaction is that devoted to plane table surveying. It is a model, both in fulness of detail and clearness of explanation. Levelling and the determination of heights are subjects that are treated with sufficient clearness, but the same can hardly be said of the "probable error." Apart from the necessarily scanty treatment, there is no mention or caution against the entrance of systematic error. In more than one place in the book, repetition of measures is insisted upon as though accuracy must of necessity follow such practice, but the mean tends to become the true value only when systematic error has been successfully eliminated. In the case of a probable error of the angles of a triangle, we have to do with a conditioned problem; apparently there is no reference to this condition, but the problem is stated so briefly that it may have been misunderstood.

The last section is devoted to astronomical observations with instructions for determining longitude and latitude. Probably this section will not be greatly used, but every attempt to familiarise the traveller with exact methods is to be welcomed. The reference to the method of finding the longitude by wireless telegraphy makes its appearance for the first time in this edition. The method will supersede the use of chronometers and all the other devices mentioned, and its importance should have been more fully emphasised. The observations for latitude are described as comparatively simple and those for longitude as complicated, but by the aid of radio-telegraphic signals, one is as simple as the other. The occultation of a star by the moon is described as the best of the absolute methods of finding longitudes, when the local time is known, and very admirable methods are given for finding the stars that are likely to be occulated at a given station, but the author has not indicated so fairly as he might have done how few are the opportunities of applying the method. The number of stars visibly occulted by the moon at any particular station in a year is very small. In a recent Greenwich volume the number of nights throughout the year on which occultations were observed was only six. And at Greenwich, fixed telescopes of considerable aperture were used. The observer with a sextant telescope would not be able to see many of the stars observed at Greenwich, and though doubtless he would carry a larger telescope, which would be available for this purpose, he would be under great difficulties. The method is excellent, but the chances of application are slender. A collection of useful geodetic and logarithmic tables concludes the first volume.

The second volume is the work of many able hands and, as evidence of ability, though prepared many years ago, very little change has been found necessary in the several sections. Dr. Mill contributes the article on meteorology and climatology, and he very rightly insists on the importance of non-instrumental observations. By paying attention to the instructions, an observant explorer will bring home a far better meteorological log without instruments, than a more careless traveller can produce by the diligent reading of many scales. This we believe is strictly true, for one is constantly reminded how much is missed by want of intelligent observation. The description of instruments conveys as much information as is needed, but no mention is made of the use of the millibar scale in the barometer. In foreign countries, and since a list of the Extra-European Weather Services is given, it is evidently intended that the traveller should avail himself of what assistance such institutions can supply. Hence, as the use of the millibar scale is more general abroad than in England, the intending traveller would be well advised to have his barometer provided with two scales, one reading millibars and the other millimeters.

The article on photography originally written by

Mr. J. Thomson, has been revised by Mr. J. McIntosh but is naturally of a very simple character. Greater or less competency in photographic manipulation is so general, that some members of an exploring party will be experts. It may be well to be reminded, however, that a person taking up photography for the first time in a few hurried moments before departure on a journey cannot expect other than very unsatisfactory results. But even the experienced photographer must be prepared for a considerable number of failures, for he labours under numerous inconveniences that are only realised by experience. Those who are undecided whether to carry sensetised plates, or films on account of their greater lightness, will do well to recall Sir Martin Conway's dictum, that "a traveller who carries glass plates and flat films will probably bring home a larger percentage of good negatives from a long mountain journey, than one who relies upon spools of films."

Professor E. J. Garwood has revised the section on Geology originally prepared by the late W. T. Blandford, F.R.S., and the article is exceedingly interesting, as it indicates the amount and character of the information that an inexperienced traveller may be expected to collect. These two authorities are of the opinion that any intending traveller who has a taste for geology—and if he has none he had better not waste any time on the subject—will find that a few months study in any good museum, a course of geological lectures, and above all, a few days in the field with a good geologist, will start him not as an expert geologist, but equipped with the great requisite of all successful scientific investigation, a knowledge of how to observe and what to observe. Qualified by this rapidly acquired and slender, if sound, stock of information how should a traveller proceed in a geologically unknown country, to collect the facts that will be both most beneficial to himself and useful to others? This is the problem discussed, and the author concludes, that the most useful record of a journey will result from an attempt to form "a sketch geological map of the route followed, with the dips and strikes of the rocks, and approximate boundaries to the formations, supplemented by notes and sketch sections." Directions are given for observing mountain chains, coasts, rivers, and lakes with other points of geological interest, and emphasis is laid on the character of the evidence needed to clear up doubts that exist on the origin of, or the variations observed in, salient features. A memorandum on glacier motion is supplied by Mr. A. G. Ogilvie, who gives specific directions for observing recent movement, and puts some very pertinent questions to which the traveller's note book should supply satisfactory answers.

The collectors of Natural History specimens are well catered for by the late H. W. Bates, F.R.S., who addresses himself, not to the expert, but to those explorers, who whilst engaged chiefly on survey, wish to know how best to profit by their opportunities of benefiting science, by collecting examples of new and rare species, and how to preserve and safely transmit such specimens. This class of explorers is recommended to apply to the Secretary of the British Museum (Natural History), who will supply any information required. The inquirer is also referred to the Handbook of Instructions for collectors issued by the Natural History Department of the British Museum.

Although many hints and directions are furnished in these chapters, naturally fuller instructions are to be found in special monographs to which reference is made. For example, the late Sir E. B. Tylor, who writes delightfully on Anthropology, and would satisfy the most eager aspirant, refers to the British Association Manual entitled "Notes and Queries on Anthropology, 1912." where fuller details are to be found on Anthropometric Measurement, Primitive Arts and Sciences, Society, Religion and Mythology, than it is possible to collect within the small space here at command. The peculiar value of this collection is that it provides an index and summary, in a convenient space, to these more complete works. The chapter on Industry and Commerce furnishes a good illustration of this method of treatment. The main features and purposes of investigation are understood by all, but Sir John Scott Keltie in a few pages keeps the salient points before the traveller, reminds him of the kind of information he is expected to collect, and provides the outline of a connected scheme which can be extended as opportunities present themselves.

To take another instance in the department of archæology, a traveller in partially explored lands, may find himself unexpectedly brought into contact with unpublished antiquities of which he feels he ought to preserve a fitting record, but of the manner of proceeding, he has neither knowledge nor acquired experience. Then Dr. Hogarth will give expert instruction, showing how he may proceed with some hope of success, by following precise directions. The enquirer is assured of a competent guide, who will tell him how to proceed under circumstances which can be fairly well forseen, and often in an emergency.

Chapters are added in canoeing and boating; on the orthography of geographical names, by Lord Edward Gleichen, K.C.V.O., and on the giving of names to newly discovered places. Considerable space is given to the care and maintenance of health when removed from medical supervision. These medical hints were originally prepared by Dr. W. H. Crosse, M.D., late medical adviser to the Royal Niger Company, but owing to the great advance in recent years of our knowledge of tropical medicine, extensive additions have been made by Dr. A. Balfour, C.B. These extensions have been the more necessary, as chief emphasis has been laid upon the care of health in the tropics, but the preservation of health is necessary in all climates and many of these hints may be followed at all times and in all places. The treatment of wounds is considered fully, and it is also remembered that the organiser of the party will be more or less responsible for the health of all those accompanying him. Hence he may be required to twist, or tie, a bleeding vessel, to use the hypodermic syringe, or even to set a broken limb. Simple rules for diagnosis and procedure are given in untechnical language, and if these directions are intelligently followed, very considerable suffering and annoyance may be avoided. Altogether travellers will find that the volumes we have been reviewing contain information of great practical value.

BOOKS RECEIVED.

Experimental Researches and Reports. Vol. III., 1919–20. Sheffield: The University, Department of Glass Technology.

Voruntersuchung und Berechnung der Grundwasserfassungsanlagen. Von Dr. J. Versluys. München und Berlin: R. Oldenbourg. [Price 7·50 marks.]

Zerkleinerungsvorrichtungen und Mahlanlagen. Von Carl Naske. Third edition, enlarged. Leipzig: Otto Spanner. [Price 160 marks.]

History of the Great War. Based on Official Documents by Direction of the Historical Section of the Committee of Imperial Defence. Naval Operations. Vol. II. By Sir Julian S. Corbett. London: Longmans, Green and Co. [Price 21*s.* net.]

Handbook of Standard Details for Engineers, Draughtsmen and Students. By Charles H. Hughes. New York and London: D. Appleton and Co. [Price 25*s.* net.]

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The Hong Kong and Whampoa Dock Company, Limited.—This company inform us that they have launched during the current year 11 units for a total of 27,267 tons gross, including a caisson dock of 240 tons. The largest units are two oil-tankers of 5,716 tons each. They have also built the engines for all these units, a total of 17,957 h.p.; these include four triple-expansion engines of 3,100 h.p., each and one of 3,300 h.p. The work in hand at the present time includes two oil-tankers of 5,229 gross tonnage, and a number of repairs.

NIDD VALLEY HYDRO-ELECTRIC INSTALLATION.

A SMALL but interesting hydro-electric power plant, recently constructed by Messrs. Vickers, Limited, for the Bradford Corporation, was inaugurated on Wednesday, the 7th inst., in the Nidd Valley, by Alderman Anthony Gadie, J.P., Chairman of the Water Committee. The river Nidd is a small stream which joins the Ouse some seven miles north-west of York, and the water supply of Bradford is at present drawn from the Angram reservoir, formed by a dam near the head of the Nidd valley. To provide the additional storage capacity which is becoming necessary a second dam, which will be known as the Scar House dam, will be constructed about 1¼ miles down stream of the existing Angram dam, and it is for the purpose of supplying power for the cranes, wire ropeways, crushing plant, and other machinery to be employed in the construction of this second dam that the hydro-electric power plant has been installed, on the suggestion of Mr. Lewis Mitchell, waterworks engineer to the Bradford Corporation.

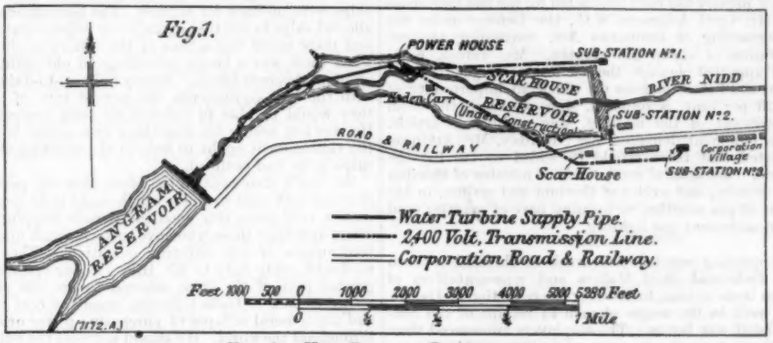


FIG. 1. KEY PLAN OF INSTALLATION.

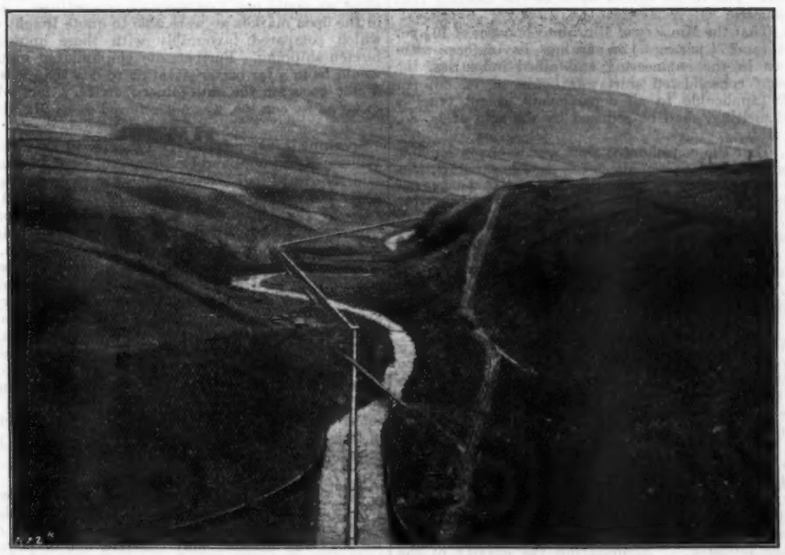


FIG. 2. VIEW OF PIPE LINE FROM TOP OF DAM.

The water collected in the Angram reservoir formerly flowed directly into the river Nidd, and was conveyed from that stream to the service reservoirs through the Rainstang tunnel, which connects with the Nidd about two miles down stream of the dam. Now, however, the water is diverted through a pipe line nearly a mile in length connected with the dam, and passes through the turbines in the power-house before running into the Nidd. The contract for the whole of the work in connection with the hydro-electric power installation was secured by Messrs. Vickers, Limited, in November, 1920, and the contract has thus been completed by that firm, and its various associated companies, in about a year.

The key plan, Fig. 1 on this page, illustrates the general arrangement of the installation, showing the relative positions of the Angram and Scar House dams, the pipe line, power house, overhead power transmission lines and sub-stations. It also shows the position of a village built to accommodate the Corporation's engineers and workmen engaged on the work in connection with the Scar House dam. This village will be lighted electrically by energy supplied by the hydro-electric installation. We may well commence our description of the installation by dealing with the pipe line, photographic views of which are reproduced in Fig. 2 on this page, and in Figs. 3 and 4 on page 824. The pipe line, which has a total length of 4,775 ft., has been connected to a previously existing 30-in. cast iron pipe in a culvert in the dam, and also to an 18-in. pipe just down stream of the Corporation's measuring weir below the dam; both connections are controlled by 18-in. valves. From the 30-in. cast-iron pipe, steel pipes of the same bore, and $\frac{7}{16}$-in. in thickness, have been installed to the point where the 18-in. pipe joins at a branch. An air valve is fitted in this pipe, which is about 312 ft. in length, to allow air to escape while the pipe line is being filled, and to prevent the formation of a vacuum if it is emptied too rapidly. From the above-mentioned point, where the pipe line proper may be said to commence, a section composed of 35-in. steel piping, $\frac{5}{16}$-in. thick and 1,484 ft. long, has been laid, and following this is a section 1,488 ft. long, composed of 33-in. piping, 0·2 in. thick. The remaining section of piping is 1,491 ft. long, 31 in. in bore, and ¼ in. thick. All the pipes are of welded steel, with flanges riveted on, the three sizes nesting conveniently for shipment. In the case of the two smaller sizes, the pipes were each supplied with loose flanges for one end, these flanges being riveted on on the site.

As will be seen from the key plan, Fig. 1, the pipe line follows the course of the river, which it crosses five times in all, temporary timber bridges being erected at the crossings. Concrete anchor blocks, anchoring rings and expansion joints were provided at various points, and where necessary the pipe line is supported on rubble masonry piers and concrete saddles. Free movement of the pipe was allowed for by inserting tough brown paper, served with blacklead and tallow, between the pipe and the concrete saddles. It may be mentioned that the maximum movement at the expansion joints observed this autumn, when the pipe line was empty, was 3¾ in., at a period when the temperature was high during the daytime and very low at night. The pipes were coated inside and out with hot tar asphalt before despatch from the works, and after erection were painted with an anti-corrosive paint. The joints were made with rubber jointing material supplied by the Ioco Rubber and Waterproofing Co., Limited, Glasgow.

A 2-in. drain valve is fitted to the pipe just before it enters the power station to allow the last section to be emptied completely, if necessary, and a 6-in. discharge valve connected by a tapered pipe to a 15-in. pipe discharging into the river Nidd is also provided near the power house. This discharge valve has been fitted for the purpose of maintaining the water supply to Bradford when the power station is not in operation. The normal consumption from the Angram reservoir, it may be noted, averages 13 cub. ft. per second over the whole 24-hour day, but as it is required to generate as much energy as possible during only eight hours a day, the turbines in the power house were designed to utilise about three times the above mentioned quantity of water. For this reason it has been necessary to increase the height of a small dam on a regulating reservoir a little down stream of the power house, where the water supply from the river enters the Rainstang tunnel previously referred to.

An exterior view of the power house is given in Fig. 5 on page 824, while Fig. 6 on the same page is an interior view showing one of the turbine-driven generators and its governing mechanism. A transverse section and plan are given in Figs. 7 and 8 on Plate XLIV, which accompanies this issue. The building is substantially constructed of rubble masonry and local stone, as also are those of the sub-stations, which will be referred to later. They were all built by a local sub-contractor, and do not call for any particular comment. Figs. 7 and 8 clearly show the connection of the pipe line to the two turbines, and also the discharge tubes from the latter. The turbines, which are of the Francis type, were constructed at Messrs. Vickers' Barrow Works to the designs of their associated company, the Société Anonyme Ateliers des Charmilles (formerly Piccard, Pictet et Cie). Each turbine is designed to develop 295 brake horse-power at 1,000 r.p.m. when supplied with 19·5 cub. ft. of water per second at a net head of 168 ft. To allow for possible variations in the water level in Angram reservoir they were, however, arranged to be capable of developing the same output with a head of 207 ft., and a correspondingly reduced discharge, and also of working under a head of 148 ft., with a correspondingly reduced output. With a net head of 168 ft., the guaranteed efficiency of the turbines was 79 per cent. at full load, 80 per cent. at ¾ load, 79 per cent. at ½ load, and 76 per cent. at half load, with a tolerance of ±2 per cent. in each case. We understand, however, that in tests recently carried out, an efficiency of 86·5 per cent. was obtained at full load. The governors are of the Piccard, Pictet oil-pressure type, each working in conjunction with a separate relief valve owing to the considerable length of the pipe line. With this arrangement, if the load is thrown off suddenly the relief valve opens very rapidly before the governor commences to close the turbine gates, afterwards closing slowly in from 80 to 100 seconds, so that the pressure in the pipe line does not become excessive. In recent tests the excess pressure in the pipe line when the load was suddenly thrown off was found not to exceed 14 per cent. of the static head.

Each turbine, as shown in Figs. 7 and 8, is coupled by means of a semi-elastic coupling to a three-phase generator, with an overhung exciter, and the output of each generator is 250 k.v.a. at 2,400 volts, and 50 cycles, when running at 1,000 r.p.m. The efficiency at full load, with a power factor of 0·8, is 93 per cent., and each generator has been tested at 80 per cent. above normal speed. The flywheel with which each set is provided, as shown in Figs. 7 and 8, has the advantage of enabling a less expensive form of rotor to be used in the generators than would be necessary if that part had to supply the whole of the flywheel effect.

The power-house switchboard, to which current is conveyed by single—core, rubber—insulated cables, is illustrated in Figs. 9 and 10 on Plate XLIV. It was constructed by the Metropolitan Vickers Electrical Company, Limited, of Trafford Park, Manchester, and consists of six panels, one controlling the two exciters, one for each of the generators and feeders, and one for the voltage regulator and lighting switches. The lighting circuit in the power-house is supplied by a small single-phase transformer of 0·5 k.v.a. capacity. Figs. 9 and 10 show clearly the general arrangement of the cubicles in relation to the apparatus, comprising isolating links, choking coils, and lightning arresters on the two outgoing feeders.

For the distribution of the power, four sub-stations will eventually be employed, although only three are shown on the key plan, Fig. 1. The location of the fourth sub-station is not yet determined, since it is dependent on the selection of a site for the quarry

which will supply the stone for the construction of the new dam. Its equipment will, however, be exactly similar to that of sub-station No. 1, which will be described later. Of the other sub-stations, two are located close to the ends of the dam on opposite sides of the valley, and the other is situated near the village above referred to. The routes of the 2,400-volt overhead power-transmission lines, which connect these sub-stations with the power-house, are indicated in the key plan, Fig. 1. The lines are of the simplest possible construction, the conductors, which are of stranded copper, being supported on "A" and "H" poles of timber. A continuous earth wire is provided throughout the system, and suitable cradles and triangular guarding are fitted where the lines cross roads or railways. Except that the lines have been very liberally designed throughout, and have been strongly stayed and supported to withstand the exceptionally severe weather conditions prevailing at the head of the Nidd Valley, their construction is in no way remarkable. It should, however, be mentioned that isolating switches are provided on each terminal pole at the various sub-stations and at the power-house, so that any section or building can be completely isolated; these switches can be operated from the ground level. The connections between the live wires and the apparatus in the buildings are made by carefully insulated wires specially designed to resist the weather, and carried down the poles to the isolating switches on reel insulators. Between the poles and the buildings, the insulated conductors are supported by raw-hide suspenders from stranded steel wires. A considerable part of the materials for the power transmission lines was supplied by Messrs. Twiss Electric Transmission, Limited, as sub-contractors to Messrs. Vickers, Limited.

The most interesting sub-station is that marked No. 3 on the key plan, Fig. 1, and illustrated in detail in Figs. 11 to 15, on Plate XLIV. This sub-station is intended entirely for the supply of direct current at 110 volts for lighting. The high-tension line is connected through a switch cubicle, shown in Fig. 13, to a 25-k.v.a. static transformer, which supplies current to a 20-kw. motor generator, shown in Figs. 11 and 12, the motor generator being used either for charging a battery or for supplying current directly to the lighting mains. The battery consists of 60 Chloride cells, housed in an annexe to the sub-station, as shown in Figs. 12, 14 and 15, and its capacity, when discharged in 10 hours to a final pressure of 1·83 volts per cell, is 979 ampere hours. As a stand-by, and for use when the hydro-electric plant is not working, a belt-driven generating unit, comprising a 35-h.p. Vickers-Petters semi-Diesel engine, and a 20-kw. generator, is provided, as shown in Figs. 11, 12 and 15. Both electric and compressed air starting apparatus for the engine are installed, and, as is the case with the motor-generator set, the oil engine set can be used either for charging the accumulators or supplying the mains directly. The low-tension switchboard, which is shown on the left of Fig. 11, and also in the plan, Fig. 12, consists of a motor panel for the low-tension side of the static transformer and the motor of the motor generator, another panel for the generator of the motor-generator set, a panel for the oil-engine driven generator, and a panel for the storage battery and lighting feeder.

The remaining illustrations, Figs. 16, 17 and 18 on Plate XLIV, show the general arrangement of sub-station No. 1, which, as shown in the key plan, Fig. 1, on page 817, is situated near the northern end of the new dam. As previously mentioned, another sub-station with similar equipment will be constructed later near the site of the stone quarry. The equipment consists of four 50-k.v.a. three-phase static transformers, designed to step down the pressure from 2,400 volts on the transmission lines to 440 volts on the feeders supplying the machinery for the constructional work. The transformers are oil-immersed in corrugated sheet-iron tanks of the self-cooling type, and both primary and secondary windings are star connected. The high-tension switchboard, an elevation of which is given in Fig. 16, comprises four transformer cubicles, while the low-tension switchboard, illustrated in Fig. 18, consists of three panels, two of which control two transformers each, while the third deals with one 50-k.v.a. feeder and one 200-k.v.a. feeder. The necessary isolating links, lightning arresters and choking coils on both the high-tension and low-tension sides, are shown in Figs. 16 and 18. The equipment of sub-station No. 2, which is situated near the southern end of the dam site, is very similar to that of sub-station No. 1, but as the former has to supply the workshops and ropeways, as well as some of the cranes, it is of rather larger capacity, containing five 50-k.v.a. transformers, with the necessary high-tension and low-tension switch-gear. This sub-station supplies two 200-k.v.a. feeders, and one 100-k.v.a. feeder. The whole of the electrical equipment for the sub-stations was supplied by the Metropolitan Vickers Electrical Company, Limited.

In conclusion, we would remark that the Waterworks Committee of the Bradford Corporation are to be congratulated for having accepted the advice of their engineer, Mr. Mitchell, to put down the water power plant we have described above. In a comparatively inaccessible district, such as the upper end of the Nidd Valley, the cost of power production from coal would have been excessive, so that, as the work of constructing the dam will occupy from 12 to 15 years, the capital expenditure on the water-power plant is fully justified. This, of course, would be obvious to an engineer, but it is not always easy to convince a municipal committee in such circumstances. As it is, the sufficient supply of cheap power will undoubtedly facilitate and expedite the work, and also materially reduce its aggregate cost.

INDUSTRIAL NOTES.

An inquiry has been conducted for the last two weeks by Mr. Cyril Atkinson, K.C., the Referee under the Safeguarding of Industries Act, concerning the importation of cheap gas mantles. Mr. Terrell, K.C., had appealed against the exclusion of gas mantles from the list of articles on which an import duty of 33·33 per cent. is imposed, since thorium, the main constituent of the mantles, was a dutiable article. In a judgment delivered last Saturday, Mr. Atkinson directed that there should be added to the list the words, "mechanical compounds of nitrates of thorium and cerium, and oxides of thorium and cerium, in the form of gas mantles, or forming part of mantles used in incandescent gas lighting."

A meeting was held last week in Sheffield between the Federated Steel Makers and representatives of seven trade unions, to consider the reduction of 11s. 6d. per week in the wages of men in receipt of the consolidated war bonus. The employers announced their readiness to make the reduction 10s., or 1s. 8d. per shift; the trade union representatives accepted this figure. The terms agreed upon at the meeting read as follows:

1. That the Ministry of Munitions bonuses of 12½ per cent. (and 7½ per cent.) on earnings, having been withdrawn in the engineering and allied industries, the present consolidated shift war bonus of 7s. 6d. per shift (applicable to all departments except crucible steel melting) shall be reduced by the sum of 1s. 8d. per shift.

2. That the consolidated shift war bonus in crucible steel melting departments, being 6s. 4d. per shift, plus the 17½ per cent., this shall be reduced to 4s. 8d. per shift plus the 17½ per cent.

3. That the above recommendation applies to all departments coming within the negotiations between the above parties with the exception of Siemens open hearth melting shops.

4. That this agreement shall commence as and from January 1, 1922.

With reference to our note on page 724 *ante*, it is now reported that an official statement has been issued by the Executive Council of the Amalgamated Engineering Union strongly advising the members to vote for the agreement on freedom of management and overtime, an agreement which was provisionally entered into with the Engineering and the National Employers' Federation. In the statement details are given of the various conferences which took place on the subject. The position, it is added, became very serious towards the end of the negotiations, as it was made clear that if there were failure to agree there would be a national stoppage of the industry. "Appreciating the gravity of the situation, and having regard to the industrial stagnation, the fact that over 90,000 members are unemployed, and the severe financial strain to which the organisation has been subjected, and is likely to be subjected for some time to come," the Executive Council accepted the agreement. Subsequently, at a conference with the National and district organisers, it was decided to recommend the members to endorse the arrangement.

It is pointed out that the continuance of the negotiations on the question of machines, apprentices, and payment for holidays is contingent on acceptance of the agreement. "Therefore," the Executive Council say in conclusion, "it is imperative that the agreement should be accepted, and thus enable negotiations on these important matters to be proceeded with."

The ballot is to be taken shortly; the result will not be known until early in the New Year.

As has happened on previous occasions, says *The Yorkshire Post*, the Bradford Corporation have again decided to give consideration to the question of new businesses and industries in Bradford. The matter has been revived by the receipt of a communication by the Finance (Accounts) Sub-Committee from the Eastern Railway Group (comprising the Great Northern, Great Eastern, Great Central, and North-Eastern Railways), asking that the Corporation should indicate what facilities they have in the way of building sites, water supply, gas, electricity, and so on to offer as inducements to industrial undertakings to establish themselves in the city. It is understood that when these particulars are supplied, the Railway Group will advertise them, and it is hoped that the result will be that Bradford will not be so dependent, as heretofore, upon the worsted industry. The Finance (Accounts) Sub-Committee appointed a small sub-committee to consider the matter.

Speaking at Sunderland last Monday, Mr. J. Hill, Secretary of the Society of Boilermakers and Iron and Steel Shipbuilders, said he regretted to see the shipbuilding industry so depressed as it was to-day. He advocated that the thirty millions provided for building the four cancelled battleships should be used in building merchant ships. It would build one hundred big ships. They had a large tonnage afloat, but one-half of the ships were unfitted for service. The Government had allowed ships to sail that ought never to leave our ports, and there never was a time in the history of shipping when there was a larger percentage of old, unfit, and obsolete steamers afloat. If they built up-to-date ships with the best equipments, the newest type of vessel, they would be able to outstrip all their competitors. He was not asking for something impossible, but said the Government ought to help in the building of such ships as he had outlined.

Mr. Hill's statement to the effect that our ports are crowded with unfit steamers which ought to be scrapped casts a very grave slur upon the British shipping concerns, and upon those who have to keep watch upon the continuance of safe shipping conditions. They will, no doubt, reply fully to Mr. Hill. In our opinion, the greater part of the ships referred to are idle simply owing to lack of trade following upon the coal strike, and the general collapse of purchasing power or credit throughout the world. We should welcome the building of new merchant ships since this would give work to a large number of men, but even whilst owning these new ships we could not "outstrip all competitors" unless in the open market we were able to quote freight rates which compared favourably with those quoted by foreign shipping. Further, our shipbuilding industry would be in a far better situation to-day than it is had it not been for the ship-joiners' strike, a fact which, so far as we can see, was not referred to by Mr. Hill.

Speaking last Monday at the annual meeting of Messrs. William Beardmore and Co., Limited, Lord Invernairn said the Board had been influenced in their decision to pay no dividend on the ordinary shares for 1919 and 1920 by the instructions to suspend the large orders which the Company had obtained from the Admiralty for a battle cruiser, armour and guns. To him, the most depressing feature of the suspension would be the inability to give employment to many thousands of men. In his opinion, a navy was to this country an absolute necessity, and justified a reasonable annual expenditure in the nature of an insurance premium. He did not desire a continuance of the exhausting policy of competition in armaments, but he thought that we could not afford to allow our naval supremacy to be lowered in any degree. Lord Invernairn also referred to the urgent necessity for large reductions in freights, and for still further reductions in the price of coal, this latter being our basic necessity.

The rights of trade union members to claim exemption from participating in a union's political funds are dealt with by "a Barrister" in *The Yorkshire Post*. He says any member may contract out of payment to this fund, but he must give due notice to his union. If the member wants exemption for the coming year, for example, he must give notice before the end of this month. The member's union—the head office or a branch office—is bound to supply him, on application, with an exemption form to fill in, or he can obtain one from the Registrar of Friendly Societies, 17, North Audley-street, London, W. 1. Another way to obtain exemption from this contribution, which in the case of some unions amounts to as much as 6d. per week, is to write out a notice in the words given by the journal from which we quote, and to send it in to his union this month for exemption in the coming year.

There remaining but a short space of time between now and December 31, this notice to trade union members—if they were unacquainted with the actual state of matters—is a very short one. Seeing, however, the apathy displayed by many trade union members to everything outside ordinary routine, it is likely that few will avail themselves of this facility, which is placed at their disposal under the Trade Union Act of 1913.

The last monthly report of the Amalgamated Engineering Union states that the membership, which stood at 460,000 at the commencement of the year, declined to just under 430,000 at the commencement of the present month, a decrease of 6·78 per cent. The latest figures showed 92,272 members, almost 26 per

cent., as unemployed. Mr. W. Glennie has been appointed assistant secretary, having obtained 50,265 votes, against 45,487 which were given to Mr. W. McLaine.

Speaking at the twenty-first annual dinner of the Glasgow and West of Scotland Association of Foremen Engineers and Draughtsmen, held last Saturday, Sir Thomas Bell said our industries had now reached the lowest depths of depression, and the difficult problem of how best to devise useful work for the great army of unemployed in our midst was receiving attention from all quarters. No one deluded himself into the belief that relief work on roads, tramways, or other navvying work, good as it was in its way, could do more than touch the fringe of our great mass of unemployment, for even as a stop-gap such relief work was hopelessly insufficient to meet the needs of any great industrial district. On such occasions they were all apt to turn to the Government for help. Many people still believed that the Government had power and resources to do practically anything, and that by some means or other it could create immediate trade, say, with Russia's starving millions, and also by some similar process remove in a brief period of time the disabilities of foreign rates of exchange, and thus rehabilitate trade with Central Europe. But, putting on one side such Utopian ideas, he made bold to reiterate the views expressed in public by one of our ablest leaders of industry, namely, that the relief of our present condition could only come from ourselves, not from the Government, and that all our efforts should be directed to encouraging the immediate resumption of work, even on the most modest scale, in each and all of the actual industries to which our unemployed workers belonged, and to which they were accustomed. By this means only could really genuine and useful relief work be provided. The most practical form of such encouragement for the resumption of industry would be the withdrawal, during this national crisis, of many trade union restrictions and agreements, so that employers, concerned in tendering for any of the few and far between contracts at present on the market, would be free to consult with their workmen and to come to agreements directly with them as man to man. They would agree that under the present circumstances many hundreds of our best workmen would only be too glad if they were free to thus co-operate with their employers in their endeavours to obtain work. If, then, this temporary concession on the part of the trade unions could only be obtained at once—not talked about for the next six months—then this, together with the sacrifice on the part of employers in their tenders of not only all profit but also a portion of their standing charges, should justify us in confidently counting on some really useful relief work being obtained ere long for large numbers of those who are at present unemployed.

We are informed that Major W. L. Foster, of Messrs. Chance Brothers and Co., Smethwick, has lodged a complaint before the Committee appointed to deal with applications under Part 2 of the Safeguarding of Industries Act, to the effect that heat-resisting glass for illuminating purposes was being imported into this country from Germany and Austria at prices below those at which similar goods could be purchased here. As a result of this competition, there was a serious risk of the industry in this country being lost altogether. When the company were induced, during the war, to take up this industry, they were told that, whatever happened, they would be looked after. If they could obtain a larger output their prices would be reduced and the number of people employed would be increased. At present only one-third of the existing plant was employed.

We referred in our last issue to the minimum wage offer of 7s. 2d. per day to the lower-paid men in the South Wales coalfield. A ballot of the lodges throughout the coalfield gave the following result:—Against acceptance, 2,468; for reference to the arbitration of Lord Buxton, 998; for acceptance of the offer, 5. The following resolution was then passed:—"That, as the wages of the major portion of the workmen employed at the collieries will not permit of the purchase of the bare necessaries of life, the Council authorise the officials to prepare a memorandum setting forth in detail the position of the industry and the wages of the workmen, with a view to making a demand that wages be made approximate to the high cost of living, and that in the meantime the Federation render every possible assistance to the totally unemployed in their efforts to secure a greater measure of relief."

The Cumberland and North Lancashire Blast-furnacemen's Associations have agreed to a revision of the sliding-scale which governs their wages. Points in the new settlement are that the wages for the next six months shall be regulated by a monthly instead of by a quarterly ascertainment, and that the employers shall have the right to raise the question of reductions below the standard rates if the ascertained price of West Cumberland mixed numbers falls to 70s. per ton. The present base and bonus payments and the present sliding-scale movements are to remain unaltered.

There are serious disadvantages in foremen and supervisors, who hold a position of trust with respect to their employers, belonging to the same trade unions as the employees themselves. No man can serve two masters, and a foreman should not be liable to censure or disciplinary treatment by his lodge on account of any action he takes in the course of his duty. This is indeed fairly recognised by some unions, and we believe that foremen are excluded from the Machinists Union in the United States. In order to provide the benefits of a trade union, in so far as legitimate protection, educational facilities and social intercourse are concerned, to foremen and supervisors in the electrical industry, the National Association of Supervising Electricians was formed in 1914. This association claims to insist upon a high technical standard as a qualification for membership, and encourages the education and efficiency of its members by means of monthly lectures. Mr. A. Brammer has recently been appointed full-time general secretary, with offices at 29, Metropolitan Buildings, 63, Queen Victoria-street, E.C. 4, and district branches are being opened in Manchester, Middlesbrough, Birmingham, Portsmouth, &c.

"ENGINEERING AS A PROFESSION."

To the Editor of Engineering.

SIR,—If it be correct that the influx of new blood into the engineering profession is now proceeding at a greater rate than can comfortably be absorbed, any advice tending to relieve such a situation should be welcome. Some of the letters on this subject you have recently published, however, are not in my opinion very helpful.

Several of your correspondents appear to consider that a commencing salary of £350 per annum is inadequate. One, reasoning from what he conceives to be the practice in other professions, thinks it strange that it should not be possible so to re-arrange matters as to retain all embryo engineers in this country. I wonder whether this latter correspondent can visualise the present condition of, say, India or other outlying parts of the Empire, had neither engineer nor doctor ever been so rash as to venture abroad. Would he comfort himself with the knowledge that the Croydon parish pump was being very thoroughly maintained at a trifling cost in engineer's salary of 500*l.* per annum?

Any endeavour to bolster up the present position by a general adoption of uneconomical salaries and the creation of "cushy" jobs at home appears to me ill-advised. On the contrary, let it be instilled into the novitiate that, twenty and thirty years ago, those who had completed their technical training were content to start in Great Britain at a salary of 100*l.* to 150*l.* per annum and that a beginner now should be satisfied with an equivalent. Further, it should be pointed out that, although the prospect of work abroad at some period may have to be faced, in such an event the resulting experience will be inimical neither to the young engineer's nor to the nation's interests.

Yours faithfully,

"B.A., M.Inst.C.E."

December 12, 1921.

"BRITISH RAILWAY STATISTICS."

To the Editor of Engineering.

SIR,—My attention has been drawn to a paragraph in the article on page 764 of your issue of December 2, upon "British Railway Statistics." The paragraph in question deals with the question of average train loads, and after pointing out that the average load works out at 132½ tons for Great Britain and that the best figure on the principal railways is 169½ tons on the Great Central, proceeds as follows:

"The North-Eastern Railway, which has made such efforts by means of organisation and advanced statistics to improve its train working, has only 153·58 tons to its credit, this being exceeded even by some lines which, before ton-mile statistics were enforced, were considered to be by no means up-to-date in their methods. It is interesting to note, now that these figures are actually available, that the model line has not been quite so far advanced in its practice as was at one time imagined."

Although well satisfied with the practical results obtained from the statistics introduced on the North-Eastern some twenty years ago by my predecessor, Sir George Gibb, I have never belonged to the school (if there be such a school) who imagine that a company which keeps ton-mile statistics can do nothing wrong and that a company which does not keep them seldom, or never, does anything right. But I am surprised that a technical paper so well informed as your own should have failed to realise that the figures of train loads published by the Ministry of Transport, if taken by themselves without regard to other factors, may prove very misleading and afford no means of comparing the operating results of different railways.

First of all, the volume of traffic to be dealt with is the main factor, and the Blue Book returns show that out of 38 companies in Great Britain whose figures are published, the North-Eastern comes thirteenth in the list in respect of the number of ton-miles conveyed per route mile per working day. It is too often assumed that the North-Eastern district is entirely a district of mines and manufactures, whereas approximately half of its route mileage serves agricultural and other thinly populated districts, where the ton-miles per route mile are not more than one-fourth of the average of the railway taken as a whole. Yet these branches must be provided with a train service, and therefore the companies which have a large proportion of main line compared with branch lines are in a relatively advantageous position.

Secondly, the nature of the traffic conveyed is an important factor, and I imagine no one will be found to deny that a company with a heavy coal traffic is in a position to obtain better loads than a company whose traffic principally consists of goods. From the Blue Book it will be seen that out of the same 38 companies the North-Eastern comes twenty-third in the list in respect of its percentage of coal and coke ton-miles to total ton-miles (and it is from ton-miles that these figures are compiled), and its percentage is in fact below the average of Great Britain. This may again surprise some of your readers. Unless the figures for coal trains are separated from those for ordinary merchandise, it is quite impossible to come to a conclusion, from figures such as those published by the Ministry of Transport, as to whether one company's train loading is really better than another's. Indeed, it is quite possible for a company to have heavier loads, both in mineral and goods, than another company, and yet to show a poorer result when the figures are combined.

Notwithstanding the above adverse factors, it will be seen that the North-Eastern in average train load comes sixth in the list. Indeed there are only two important companies with greater average train loads, and both of these have distinct advantages over the North-Eastern in their ton-miles per route-mile and in their proportion of coal and coke ton-miles.

There are many other factors which have a bearing upon the attainment of big train loads, such as gradients, locomotive capacity, average length of haul, the proportion of pick-up services to through train working, and the strength of bridges and viaducts. Such factors are always taken into account by anyone conversant either with railway statistics or the practical problems of railway operation, but as many of your readers may not be conversant with either and may draw erroneous conclusions from the paragraph in your article to which I have drawn attention, I shall be glad if you can find space in a future issue of your paper for the publication of this letter, the object of which is to warn the unwary from making comparisons between the relative efficiency of different companies from figures which, in fact, throw no light upon that question.

I am, yours faithfully,

A. Kaye Butterworth.

North-Eastern Railway, General Manager's Office, York, December 8, 1921.

[We gladly publish Sir A. Kaye Butterworth's letter for the benefit of those of our readers who may not realise the many factors that affect the attainment of big average loads.—Ed. E.]

British Trade Ship.—Referring to the information given in several of our former issues concerning the British Trade Ship, we are now informed that the terms to exhibitors have been reduced following falls in market prices. Particulars can be obtained from British Trade Ship, Limited, 12, Grosvenor-gardens, S.W. 1.

Machine Mining.—The machine mining of coal is dealt with in a very complete and interesting manner in the illustrated monthly magazine issued by Messrs. Mavor and Coulson, Limited, 47, Broad-street, Mile-end, Glasgow. The issue for the current month deals with bar coal-cutting machines, roof and pillar workings, extracting pillars by machinery, &c.

The British Industries Fair and Export Trade.—The Birmingham Section of the British Industries Fair, which comprises the metal and engineering exhibits, will be held as heretofore in the aerodrome buildings at Castle Bromwich, from February 27 to March 10 next year. This section, thanks to the business energy of the local committee and to the excellence of the site for exhibition purposes, has been particularly successful on previous occasions in attracting foreign buyers, and there is every hope that the success will be repeated next year. The Trade Facilities Act, 1921, which became law on November 10, is a distinct advance on The Overseas Trade (Credits and Insurance) Act of last year, which contained so many restrictions that few firms could benefit by it. The new Act, which embodies the provisions recommended by the Association of British Chambers of Commerce, is not only more businesslike, but it applies to transactions in all parts of the world except Russia and India. The latter country is excepted only because the Indian banks are prepared to grant any assistance or credit necessary to their merchants. At the British Industries Fair there will be a bureau under the management of the Export Credit Department of the Department of Overseas Trade, especially for the convenience of merchants who require credit under the Act. Thus overseas buyers can inspect the goods, and if they desire to purchase, the exhibitors can arrange at once for such liberal terms of credit that no sale should be lost owing to any difficulty the buyer may have in making prompt payment. The facilities which the new Act confers should be known to all manufacturers and merchants, and it is to be hoped that the assistance it affords towards financing overseas trade during the present difficulties will result in valuable business being secured at the Fair.

NEW YORK CENTRAL RAILWAY SYSTEM CONTAINER CARS.

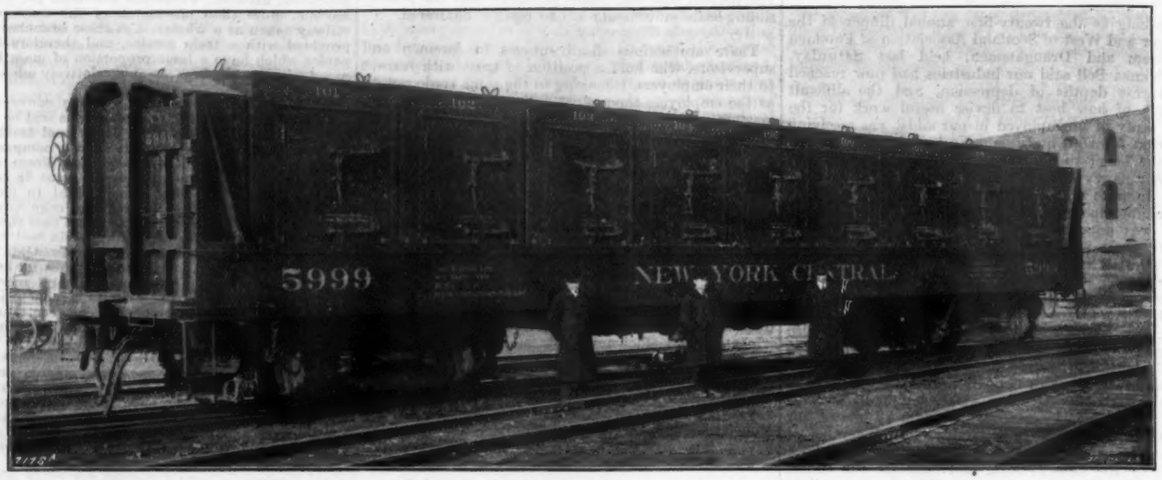


Fig. 1. Express Type of Container Car Loaded.

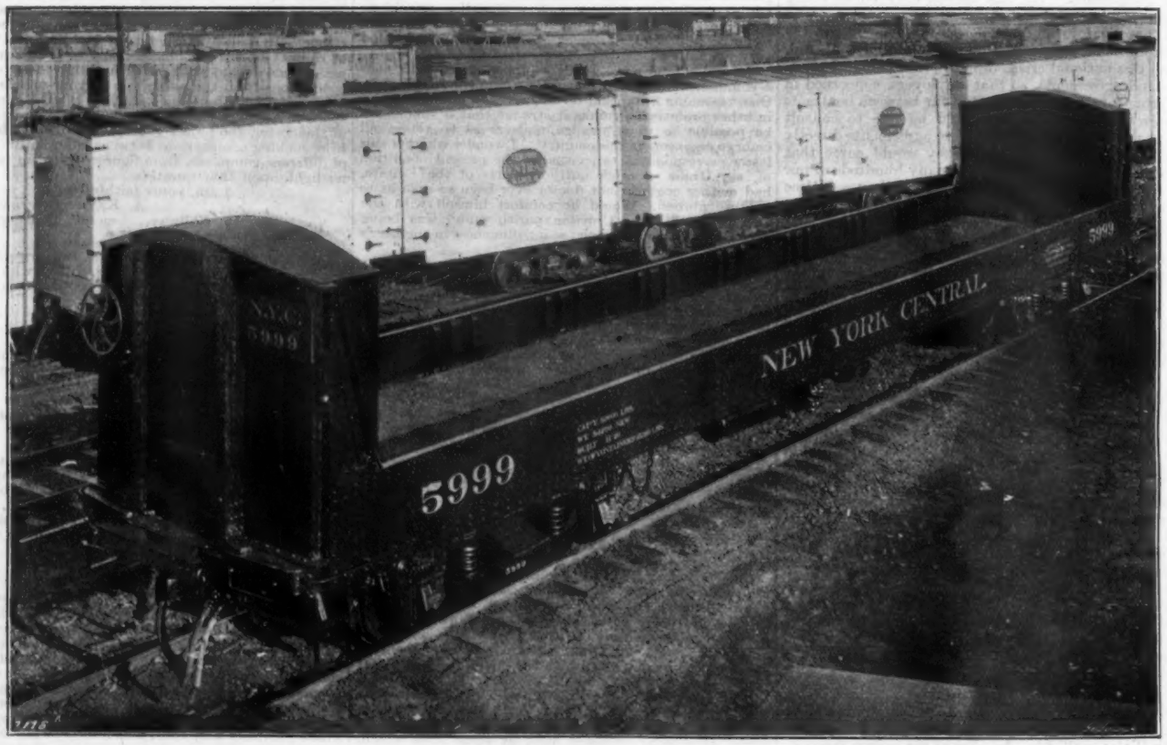


Fig. 2. Express Type of Container Car Empty.

The use of containers for railway traffic in small lots has frequently been advocated, and the principle has in certain services been adopted with success. For instance, in the Continental traffic the loading of baggage registered through to Paris from London, in containers, expedites the transfer at the Channel ports to a considerable extent. In theory for certain types of traffic the container presents obvious advantages provided the difficulties which it introduces are satisfactorily overcome as regards organisation, handling, &c. We place organisation first, because a breakdown in this at once results in the failure to realise the economies expected, and it is essential therefore that the container system, if introduced, should be worked regularly and methodically.

The most obvious reason for adopting the container system from the shipper's point of view is the protection the method provides for less than car-load shipments of freight which is liable to damage in transit, coupled with the advantage of loading and unloading at leisure. From the railways' point of view the chief advantages are the quick release of rolling-stock at destination, and the protection afforded against pilfering from small consignments. We have heard a good deal unfortunately about the latter, in all countries, since the war, which seems to have had a regrettable influence in relaxing the high pre-war standard of integrity of railway employees. This phase has been marked in the United States as in European countries, and, with a view to coping with it to some extent, the container system is being introduced on the New York Central Lines. It will be clear that, with the large freight and express cars employed in the United States, the time taken in loading small parcels of goods must be far greater than is necessary in the case of small wagons here. Although every endeavour is made by shippers to arrange for car-loads, the smaller consignors have to rely on the integrity of the various agencies and express companies whose business largely consists of building up, for the railway companies, car-loads out of less than car-load lots. The adoption of the container would of course materially increase the number of shippers making use of a sealed unit, the container being sealed up on the consignors premises, delivered to the railway in this condition, and not unsealed until after receipt by the consignee. The security offered therefore by car-load shipments, with its immunity from intermediate

NEW YORK CENTRAL SYSTEM CONTAINER CARS.

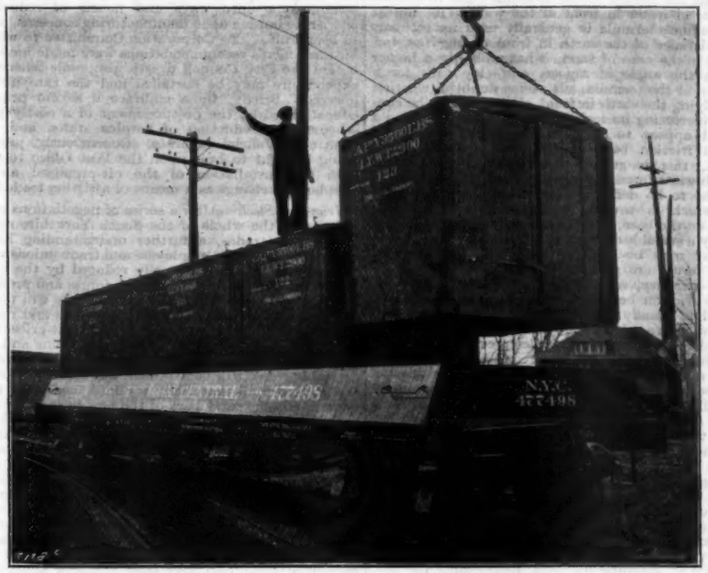


FIG. 3. UNLOADING CONTAINERS FROM FREIGHT TYPE CAR.

FIG. 4. CONTAINER LOADED ON MOTOR LORRY FOR DELIVERY.

handling, transhipment and re-packing, is within the reach, with the container system, of the smaller shipper. This principle is widely accepted: the moot point is to know how to put the system into practical shape.

The manner in which the question is being tackled on the New York Central Lines is illustrated in Figs. 1 to 4 on this and the previous page. A paper on the subject of "Avoidable Waste in Car Operation—the Container Car," was read on December 6 by Mr. W. C. Sanders, of New York, before the American Society of Mechanical Engineers, and we are indebted to this for the following particulars of the stock. Figs. 1 and 2 show a type of car designed for express traffic. The car is of steel construction with low sides and raised ends. It is fitted throughout for use with standard passenger equipment. The car is 61 ft. 3 in. long, and takes nine containers, each 9 ft. wide, 6 ft. long, and of 7 ft. 4 in clear height inside. The door is 3 ft. by 6 ft. The containers are of steel, with wood floors. Eyes are fitted at the top corners for lifting. The doors are the standard refrigerator car design, with hasp and staple, and pin and slot for car seal. The containers are each rated at a capacity of 7,000 lb., and they are as nearly burglar proof, weather and fire proof as it is possible to make them.

Fig. 2 shows the car empty, and from this it will be clear that the containers fit in between the low sides, and are held in place by guides riveted to the car sides. These guides are channel-shaped and of $\frac{1}{4}$ in. steel plate pressed to shape. Corresponding with these guides are fitting shoes riveted to the containers, close to the corners. The containers fit between the sides with a clearance of $\frac{1}{4}$ in. on either side, and are kept in place by the guides, so that neither packing, blocking nor lashing is required, and a car may, if necessary, be moved safely with less than the complete number of containers in place.

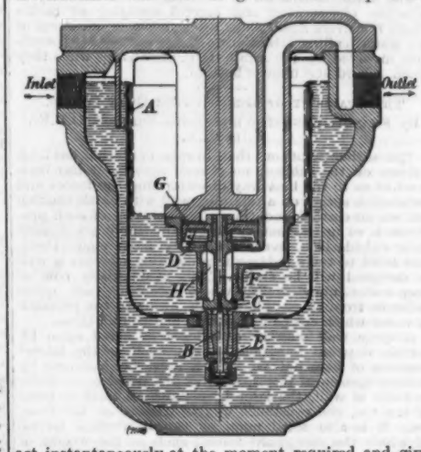
The type of freight car in use is shown in Fig. 3, but this car is shown with two large and two smaller containers. As a matter of fact the large containers have been abandoned in favour of the smaller sized unit, and the standard complement is six containers each 6 ft. 7 in. in length, 7ft. $1\frac{1}{2}$ in. in width and of 7 ft. $7\frac{1}{4}$ in. clear height—all inside measurements. These containers ride on a car 50 ft. long, which is 9 ft. longer than the longest New York Central box car. In this case the containers are made with steel frame, base and roof, with wood walls. The doors, as will be seen from Fig. 3, are in the width side, and $\frac{1}{4}$ in. steel plates are riveted across the car to form low bulkheads between the container positions so as to prevent any door being opened while the cases are on the car, in the event of the total being incomplete. In the same way the doors for the express type described above, are prevented from opening when they are loaded, by the low sides of the car. Fig. 3 shows one of the containers being unloaded, and Fig. 4 shows one loaded up ready for delivery. It will be noted that it is placed so that the door comes up against the back of the driver's seat, and it cannot be opened, therefore, till after lifting by a crane—an additional safeguard against tampering.

The New York Central is putting into service new container cars intended for mail traffic, in which connection some very successful tests were carried out last May, when New York mail was delivered in Chicago and beyond in times never before attained. The new mail cars now being built are to be 59 ft. $11\frac{1}{2}$ in. between ends, affording room for eight containers 7 ft. $2\frac{1}{2}$ in. overall with 2 in. clearance between every two. The containers will be 8 ft. $10\frac{3}{4}$ in. wide and 8 ft. 2 in. in height overall. They are of steel throughout, the ends being strongly reinforced by pressings of steel riveted to the frames and panel plating.

There is of course a certain loss of accommodation by the use of containers, but the advantages for certain traffic would outweigh this slight disadvantage. The quick release of the car and consequent improved service is expected to go a long way to compensate for this. In the postal trials referred to the unloading of nine containers and their dispatch to the post office was accomplished in Chicago in 21 minutes, and in New York in 18 minutes, when the car was freed for others to be loaded up. The 37,000 lb. of mail could not possibly have been cleared in anything like these times with loading on the ordinary method.

THE "RECORD" STEAM TRAP.

AMONG the fittings of a steam plant there is perhaps none which has earned for itself more objurgation than the steam trap. Such devices after a very short period of service are apt either to cease to function altogether or to suffer from a continual leakage of steam. Their ineffectiveness is in many cases due to the absence of sufficient power to open and close positively when circumstances demand. A good steam trap must



act instantaneously at the moment required and give a free discharge. In order to get rid of the water as rapidly as it arrives, a trap must have a comparatively large valve, a feature which it is practically impossible to incorporate in a design dependent upon the direct action of a floating bucket for its operation. In the "Record" steam trap, a sectional drawing of which is reproduced in the figure herewith, a floating bucket is used to operate a relay valve, which admits the water under pressure behind a large loosely fitting piston connected to the main valve. By giving the bucket very little work to do and utilising the steam pressure within the trap to open and close the main valve a powerful and positive action is assured.

The action of the trap will be understood by reference

to the figure. The water enters the trap and causes float A to rise, and in doing so it closes pilot valve B. Water then accumulates until it overflows into float A and causes it to sink. When the float sinks the collar E pulls downwards the pilot valve B, thus allowing water under pressure to pass up through the hole F in main valve to the top side of piston G. The pressure on the piston—which is at least six times the area of the main valve—immediately presses it downwards and opens the main valve C, the contents of the float being instantaneously discharged. The float then rises and closes the pilot valve B, thus cutting off the pressure supply to the top of piston G, and as this piston is an easy fit in its casing, the pressure is at once lost, and the main valve C is closed. A light spring D is also fitted to ensure prompt closing. To prevent trouble due to corrosion all internal parts are made of non-corrosive metals.

The trap has been supplied in considerable numbers, and has, we understand, proved particularly successful in practice. It is manufactured by the Record Engineering Company, Limited, of Tutbury, Burton-on-Trent.

DEEP-WATER QUAYS.*

Deep-Water Quays: General Considerations of Design.

By Ernest Latham, M.Inst.C.E.

The author refers to the notes and discussions read before Section II of the 1921 Engineering Conference and the difficulties of dockising the River Thames. The paper is restricted to experience on the River Thames and its estuary and to general considerations of design governing the construction of deep-water quays. It is divided into two sections, dealing first with structural considerations, and secondly with the question of berthing facilities. Present-day costs are referred to as one of the principal factors governing design and several existing deep-water quays in the Thames are cited.

The relative advantages of open piled structures and quays designed on the "cylinder" system are discussed, and examples are referred to, the "cylinder" system in general being preferred by the author. The driving of fished Oregon timber piles is dealt with, and details of the fish-joint and "set" are given. The difficulties of constructing cylindrical piers in deep water are referred to, and the general outline of a deep-water quay now under construction at Thames Haven, Essex, is illustrated. The question of berthing facilities is raised especially with regard to the difficulties of mooring big ships in tidal waters where there is a considerable range of tide.

The relative advantages of a jetty and dolphins, and a continuous quay, are reviewed and discussed. The author points out that on a continuous quay-face constant attention to mooring ropes is necessary, and an actual example of the mooring of a 12,000-ton ship in the Thames estuary is illustrated. The suggestion of a compromise between a jetty and dolphins, and a deep-water quay, is thrown out, and such a design now under course of construction is given in general outline.

The author concludes by referring to the necessity of constant observation and careful dredging at berths where relatively small ships are partially water-borne at low water, calling attention to the considerable expenditure involved by the straining of such ships when they touch a hard and uneven bottom.

The Stability of Deep-Water Quay Walls.

By Francis Ernest Wentworth-Sheilds, O.B.E., M.Inst.C.E.

The author points out that, in spite of all that has been written on the subject, no general agreement has been reached as to the best way of estimating the forces and resistances acting on a retaining wall with earth backing and on an earth foundation. The solution of such problems is so unsatisfactory that many engineers discard their calculations, even when they have made them, and trust to their judgment in deciding whether a wall as designed will be stable. This is especially true of deep-water quay walls, whose problems are quite different from those of land walls, owing to the presence of water which creeps underneath and behind them.

A quay wall may be considered as acted upon by certain outward horizontal forces, such as the lateral pressure of backing, &c., which must be balanced by inward horizontal forces, such as the pressure of water in front of wall, the lateral resistance of earth in front of the toe, the resistance due to friction at the base, &c. It is also acted upon by certain vertical forces, of which the downward forces, such as the weight of the wall, &c., must be balanced by the upward forces, such as the upward pressure of water and earth beneath it. Moreover, the sum of the moments of all these forces about any point must be zero, or the wall will overturn. As regards the outward forces, the most important is the lateral pressure of the earth backing, for estimating which engineers generally use Rankine's formula. Mr. Crosthwaite's experiments show that to obtain accurate results with sand the value of ϕ should be greater than the angle of repose, and Mr. Bell has shown that the formula needs modification in the case of clay. If the backing is flooded, it is suggested that the intensity of its pressure should be estimated as that of water, whose free surface is at soakage level, or of the earth alone, whichever is the greater. Loads on the quay are generally taken at about 2 cwt. per square foot, and heavy point loads may be regarded as dispersed over a certain area. The pull of a ship on the bollards may also be considered as dispersed over a certain length of wall.

As regards the inward forces, it seems right to include the pressure of water in front af the wall at its lowest level. Rankine's formula is generally used for estimating the resistance of the earth in front of the toe, but here again, in the case of sand, ϕ has probably a higher value than the angle of repose, and clay calls for a modification of the formula. It seems doubtful whether water overlying the earth in front of the toe can be considered as increasing its resistance. A sloping base to a wall would appear to produce an inward resistance. As regards friction between the wall and the earth beneath it, this is generally obtained by deducting the other inward forces from the outward forces. The result ought to be definitely less than the permissible friction, which is usually estimated by multiplying the weight on the base, less the upward pressure of water under it, by a suitable coefficient. Such coefficient in the case of clay may be little or nothing. The vertical downward forces are generally assumed to include all materials—masonry, earth and water, directly over the base. The friction between the backing and the back of the wall is usually ignored, though in certain cases it may come into play. The upward vertical forces are generally assumed to include pressure of water under the base due to a head equal to the height between the base and the lowest water-level. The friction between the toe and the earth in front of it is commonly ignored. The remaining force, which is the upward resistance of the earth under the wall, is found by deducting the other upward forces from the downward forces. Then by taking moments of all forces about any point, the position of the resultant of this earth resistance can be found, and hence its greatest intensity. This again should be definitely less than the permissible resistance or bearing power of the earth, which is estimated in various ways, and in many cases can be determined by experiment.

Some devices for stabilising a wall, such as widening or deepening it, stepping its back, lengthening the toe, removing part of the backing, are considered from the standpoint of theory and of experience. It is suggested that as there is now a large amount of information available about the behaviour of quay walls under various conditions, such information should be collected and analysed, with a view to laying down satisfactory rules for wall design.

* Abstracts of papers read before the Institution of Civil Engineers, Tuesday, December 13, 1921.

The Wagon Association.—This Association, whose address is 11 and 12, Coal Exchange, E.C. 3, has issued a circular to private wagon owners, colliery companies, colliery owners, and others, announcing its formation, and stating its objects, which are the following: (1) To protect the interests of private wagon owners generally. (2) To advise members on all matters relative to wagons. (3) To watch the interests of wagon owners, especially in relation to parliamentary and other matters. (4) To watch closely and keep in touch with Government Departments, the Railway Clearing House, and the railway companies, as regards regulations relative to wagons, *e.g.*, alterations in specification, standardisation of wagons, railway rates, haulage, &c., and more especially to follow closely the attitude of the railway companies as regards private wagon owners. (5) To obtain preferential terms for its members by collective bargaining with repairing firms, for which purpose a very complete schedule of repair charges will be drawn up and agreed with repairing firms as a maximum. This schedule, the prices of which will be revised as necessity arises, will be issued to members together with a list of repairing firms agreeing, and each member will be at liberty to negotiate direct with any firm or firms on the list. The association will also inspect members' wagons whilst under repairs and to expedite repairs. Further information and terms of membership can be obtained on application to the above address.

Lloyd's Returns of Vessels Lost, &c.—Statistics recently issued by Lloyd's Register show that during the first quarter of this year 75 steamers, making 118,430 gross tons, and 43 sailing ships, making 28,538 gross tons, were lost to the maritime nations of the world, mainly from accidental causes. The British losses for the quarter included 15 steamers (16,228 tons) and 3 sailing ships, making 1,321 tons, the steam tonnage lost representing 0·09 per cent. of the steam tonnage owned in this country, while the corresponding figure for the sailing tonnage is 0·60 per cent. Between them, the British Dominions lost 8 steamers with an aggregate tonnage of 8,423 and 11 sailing ships making 2,740 tons, these losses amounting together to 1·25 per cent. of the total tonnage owned in the Dominions. The United States lost 4 steamers (10,757 tons) and 12 sailing ships with an aggregate tonnage of 14,577, which amounted to more than 1 per cent. of the total United States sailing tonnage. In the case of Norway, the sailing tonnage lost was nearly 1·7 per cent. of the total, the actual figure being 4,043 tons comprised in 3 vessels; the Norwegian losses of steamers were, however, proportionately smaller, amounting to 6,207 tons (5 vessels), which is about 0·31 per cent. of the steam tonnage owned in Norway. The chief sufferer during the quarter was Spain which lost 9 steamers with an aggregate tonnage of 19,513, as well as 2 small sailing ships; the steam tonnage lost in this case amounted to over 2 per cent. of the total. The only other nation whose total losses during the quarter exceeded 10,000 tons is France, that country having lost 2 steamers making 9,490 tons and 2 small sailing ships of 583 tons together; the proportion of steam tonnage lost to France was 0·32 per cent.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Reducing the Rates Burden.—The exhaustive inquiry made by the Committee of Sheffield business men—including many of the leading engineering masters and steel-makers—into ways and means of reducing the city's rate burden upon manufacturing concerns, promises to bear fruit. The Corporation Committee to whom the business men's recommendations were made have placed before the City Council drastic proposals whereby city expenditure may be curtailed and the rate ultimately lowered. Briefly, these embrace a severe pruning of education costs, the postponement of a costly printing scheme, the reduction of surplus staffs, and a keen scrutiny of official expenses. Concurrently, pressure is being brought to bear upon the Post Office to proceed with the installation of the oft-promised automatic telephone exchange as a means of assisting trade revival.

Iron and Steel.—After a series of negotiations covering practically the whole of the South Yorkshire steel and engineering trades, a further understanding has been reached between the employers and trade unions whereby wages costs will be materially reduced by the cancellation of war bonus awards. Mills, forges and press shops, crucible and electric furnace departments will now have a better opportunity of attracting orders and restarting idle plant by offering to undertake work at prices more in keeping with the purchasing power of home and foreign customers. No guarantee can be given that this desirable result will be attained, but the hands of manufacturers are so materially strengthened that there is little doubt the early part of the new year will witness a reduction in Sheffield's 47,000 unemployed, which total includes 40,000 operatives wholly dependent upon national and local relief agencies. Continental competition in raw and semi-finished iron and steel is weakening rapidly. Outstanding contracts are not being worked out to time, and the advance in prices of materials, particularly from the Belgian area, has brought them so closely into comparison with British rates that buyers are re-opening home connections. This factor is expected to exercise a marked improvement on the output of local iron and steel furnaces when current stocks have been dealt with. Progress in business in railway rolling-stock and materials is disappointingly slow. Most of the foreign orders on hand are nearing completion, and at the moment there seems little prospect of obtaining contracts to replace them. Home railway companies cannot be tempted beyond comparatively small orders for renewals. Wagon repairs are providing a lot of work, evidently in anticipation of more active conditions in 1922. The recent expansion in the automobile section has not proved sufficient to justify the restarting of idle departments. Agricultural engineers are gradually being driven into a state of despair by the unrelieved depression of the machinery market. The prospects of tool makers are improved by the fact that a further wages reduction of 12½ per cent. comes into operation as from January 1. Sheffield's largest multiple tool concern aims at establishing first-hand connection with retail buyers, by opening its own shops. Builders complain of the strangling effect of Government subsidies on unassisted private enterprise, but at the moment there is an improved demand for constructional ironwork.

South Yorkshire Coal Trade.—The long-expected expansion in house coal business has at last materialised, with the result that stocks at many depots have been exhausted and merchants are thrown upon day-to-day supplies from collieries. The metropolitan demand for cheaper rates is not reflected in the price of the best grades. Secondary sorts are being sold at widely different prices, but current requirements are mostly for the best-known brands. The position in regard to export business in steam hards is unchanged. Prospective buyers are holding off in anticipation of reduced freights. Home manufacturing concerns are not buying large stocks to cover new year requirements. In their opinion the trend of business is not sufficiently marked to warrant heavy commitments. Gas and electricity concerns are taking full deliveries to cover the holiday season. Selling pressure in smalls is chiefly confined to inferior grades. There is no change in either blast-furnace coke or steel coke. Quotations: Best branch hand-picked, 39*s.* to 40*s.*; Barnsley best Silkstone, 38*s.* to 40*s.*; Derbyshire best brights, 35*s.* to 36*s.*; Derbyshire best house coal, 34*s.* 6*d.* to 35*s.*; Derbyshire best large nuts, 30*s.* to 32*s.*; Derbyshire small nuts, 27*s.* to 29*s.*; Yorkshire hards, 29*s.* to 30*s.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; rough slacks, 17*s.* to 18*s.*; nutty slacks, 15*s.* to 16*s.*; smalls, 5*s.* to 10*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Imports of Continental foundry iron to Teesside have almost ceased as Cleveland pig-iron can now be bought here cheaper than can foreign material, but owing to high railway charges foreign makers are still able to compete successfully with Cleveland producers in other home markets. A drastic cut in railway rates is considered essential. Coastwise shipments of pig-iron show some improvement. The five furnaces that are running on Cleveland pig-iron are turning out more iron than is required, but very little movement in the direction of increased demand would quickly take up all supplies. Makers adhere to their fixed minimum quotations. No. 1 is 105*s.* for home use and 110*s.* for export, and No. 3 G.M.B. is 100*s.* for home use and 105*s.* for export. The lower grades are abundant and continue very slow of sale. Quotations for home purposes, and for despatch to foreign destinations, are identical; No. 4 foundry is 95*s.*, No. 4 forge is 90*s.*, and mottled and white are each 85*s.*

Hematite.—Hematite prices are not fixed, and producers, not being at all hampered in this respect are competing keenly for contracts, with the result that prices are falling notwithstanding that East Coast brands are already the cheapest hematite in the country. The 13 furnaces that are blowing on hematite are producing a good deal more iron than is needed, but makers have confidence in the future, and look for increased demand before long. For export, as well as for home consumption, No. 1 is on sale at 105*s.*, and Nos. 1, 2 and 3 are offered at 102*s.* 6*d.* In their eagerness to book orders makers are not averse to giving favourable consideration to offers at slightly below even these reduced rates.

Foreign Ore.—Business in foreign ore is hardly heard of, as consumers are still off the market, having large stocks and heavy supplies to take up in fulfilment of old contracts. Best rubio is round about 27*s.* c.i.f.

Coke.—Coke continues to fall, and local users are holding off. For early business Durham blast-furnace coke, of average quality, is quoted 28*s.* delivered, but forward contracts can be arranged at a good deal less.

Manufactured Iron and Steel.—Output of finished iron and steel has dwindled to very small dimensions, and prospects at present cannot be described as otherwise than gloomy and discouraging. Further fall in prices seems imminent. Common iron bars are 12*l.* 10*s.*; iron rivets, 16*l.*; soft steel billets, 7*l.* 10*s.*; medium steel billets, 9*l.*; hard steel billets, 9*l.* 10*s.*; steel boiler plates, 16*l.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel joists, 10*l.* 10*s.*; heavy steel rails, 10*l.* 10*s.*; fishplates, 15*l.* 10*s.*; and corrugated galvanised sheets, 17*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

The State of Trade.—The depression which has gradually settled down over practically all industries throughout the country shows little sign of lifting except in one or two isolated cases. Some trades have had a turn of work recently, but already that has dried up, and once again there is very little doing. In the major'ty of the works and factories the activity referred to consisted of urgent lots to cover immediate needs, and when these were worked off there was little else booked to follow on and dull times have again become all too general. In the iron and steel branches the want of business has been keenly felt and the horizon continues clouded. Engineering shops are all more or less on short time and little fresh business is on offer, and in many cases it is old contracts alone which is managing to keep the wheels going round even to a limited extent. The shipbuilding industry is really in a bad way and new contracts are meantime non-existent, with the result that each month sees an increase in the number of yard hands thrown on to the idle list. With general costs coming down steadily there is rather a better outlook for the shipbuilder, but prices must come down a good deal further before owners will feel inclined to order new vessels. Textile firms are generally very quiet, and only a few establishments are busy. The im ediate outlook on all sides is not very bright, but there is quite an optimistic spirit prevailing that business will improve considerably with the turn of the year.

Scottish Steel Trade.—The steel trade of Scotland is still extremely dull, and there is little work on any order books. The favourable inquiries which have been on the market recently have not resulted—except in a few cases—in business, and no matter how active the selling departments have been the booking of new orders has been extremely difficult. The "freeing" of prices recently suited the buyers to a nicety, and now that the English makers can offer in this market the competition is very keen, and a goodly share of the little business going around is being secured for the south. The makers of black sheets do not report any improvement, having followed the latest cut in prices, but as the new rates are likely to remain steady for a bit it is anticipated that a fairish amount of new business will shortly be given out. Inquiries from abroad are again better; Australia, the Argentines, and the Far East are each in the market, and hopes are high that satisfactory dealings may follow. The current prices are as follow:—Boiler plates, 14*l.* per ton; ship plates, 10*l.* 10*s.* per ton; and sections, 10*l.* per ton, all delivered Glasgow stations; and sheets, 12*l.* 5*s.* per ton, delivered Glasgow or equal.

Malleable Iron Trade.—The position at the various malleable iron works in the West of Scotland has not changed and part time only is being worked. The demand for bar iron is very limited and bookings are not heavy, while fresh inquiries, which have been moderately good of late, have not resulted in any very satisfactory volume of business. Prices are steady this week, with "crown" bars called 12*l.* 10*s.* per ton delivered Glasgow, which is 15*l.* per ton under the top price of the year.

Scottish Pig-Iron Trade.—The amount of business going through in the Scottish pig-iron trade continues on the small side, and consumers are very slow to place orders, with the result that the output has again been curtailed. A few more furnaces were damped down towards the end of last week, including one which was on hematite iron, and there is the prospect of a further reduction in the number in operation next week. Producers have recently been doing everything in their power to secure business, sufficient to maintain their staffs, but buyers will not be induced to book ahead, even although very favourable terms have been offered once or twice. Prices are the turn softer over the week, and in the case of hematite the quotation is 5*s.* easier at 6*l.* per ton, net, delivered at the steel works. Foundry iron No. 1 is called 6*l.* 5*s.* per ton, and No. 3 is 6*l.* per ton, both net ex-makers' works. The total number of furnaces now in blast in Scotland is only 12, whereas there are in all about 100 which could be worked if necessity demanded it.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The steadier feeling which has pervaded the coal markets of late is reflected in the official returns showing the average export prices obtained in November. In previous months since the termination of the national strike a continuous drop has been shown, but in November a few advances were recorded over the October averages. Large steam coal shipped from Cardiff in November averaged 30*s.* 11*d.* compared with 32*s.* 8*d.* in October, and steam smalls 17*s.* 2*d.* against 16*s.* 8*d.*, while large exported from Newport averaged 31*s.* 2*d.* against 31*s.*, and small 20*s.* 9*d.* against 20*s.* 1*d.* Steam large shipped from Swansea averaged 28*s.* 10*d.* against 31*s.* 4*d.*, and smalls 20*s.* 10*d.* against 19*s.*, while large exported from Port Talbot averaged 28*s.* 10*d.* against 36*s.* 11*d.*, and small 16*s.* 7*d.* against 16*s.* 6*d.* Prospects are brighter than has been the case for some months past, as there are numerous inquiries for shipment next year. At the same time, collieries generally are fairly well booked up and on paper have full stems till the end of the year. Business, however, is a little less active due to the fact that most buyers have covered their requirements over the holidays. For current business, best Admiralty large is firm at 25*s.* to 25*s.* 6*d.*, with seconds at 24*s.* 6*d.* to 25*s.*, and the leading Monmouthshires from 23*s.* to 24*s.* Smalls of all grades, with the exception of drys, are scarce, and for best steams by themselves sellers ask up to 20*s.*, but if buyers take a proportion of large they can secure supplies at 18*s.* 6*d.* with other grades at relative levels.

Iron and Steel Trades.—Trade is improving steadily, and about 85 per cent. of the mills are now working. Export business is rather quieter, but the home demand is brisker. Prompt tin plates are on the basis of 21*s.* f.o.b. and 20*s.* 9*d.* f.o.t. forward.

Two More Shipping Companies Fail.—The banks have taken possession of two more Cardiff shipping fleets and placed them under the management of nominees. The companies concerned are the Stella Shipping Company, Limited, with three steamers aggregating 20,000 tons, and the Midland Counties Shipping Company, Limited, with 1 steamer of 4,800 tons. Both companies were under the control of Mr. W. A. Hepburn, of Cardiff, and the issued capital involved amounted to just over 305,000*l.*, of which 306,000*l.* was subscribed to the Stella Company. The failures are attributed by the managers to "oppressive taxation, and the extraordinary general depression that has passed over the shipping industry." Meetings of both companies have been called at which resolutions will be put proposing voluntary winding-up and the appointment of a liquidator. In the case of the Stella Company it is stated in the circular to shareholders "a contract was made for the purchase of a new steamer at an approximate price of 170,000*l.*, and on account of that contract your company paid 108,000*l.* By the time the steamer was launched the price of labour and material had so increased that the purchase price had gone up to about 210,000*l.*, and the value of the steamer by reason of the depression had decreased to below 70,000*l.*"

PROPOSED INSTITUTION OF CHEMICAL ENGINEERS.—The first meeting of the provisional committee of this proposed institution was held on the 7th inst., at the offices of Sir Arthur McDougall Duckham, 52, Grosvenor-gardens, S.W. 1. Sir Arthur was elected chairman, and Mr. W. J. U. Woolcock, M.P., vice-chairman. The hon. secretary, Professor J. W. Hinchley, reported that a number of donations had been received and promised, amounting in all to about 500*l.* It was agreed that the next meeting of the provisional committee be held on Wednesday, the 21st inst.

THE MINERAL RESOURCES OF YUGO-SLAVIA.—The territories embraced within the new State of Yugo-Slavia include Serbia, Serbian Macedonia, Bosnia, Herzegovina, Dalmatia, Slovenia, Croatia, Slavonia, and the southernmost portion of the former Kingdom of Hungary mainly inhabited by Slav peoples. It has a total area of about 86,800 square miles, and a total estimated population of 12,000,000. True stone coal does not exist in any large quantity in Yugo-Slavia, practically the whole of the coal mined being either brown coal of the Mesozoic Age, or lignites of the Tertiary Age; these occur plentifully, according to a report by Mr. D. A. Wray, to the Department of Overseas Trade, and the reserves of both are considerable. Deposits of peat occur in numerous parts of the State, but they are merely of local importance. In the matter of iron-ore, it is probable that total reserves of workable ore are relatively speaking, not very great; those of Bosnia are considered to amount to 22,000,000 metric tons, made up mostly of limonites, siderites and hematites. According to another authority, the potential reserves of these three classes are said to amount to 100,000,000 metric tons in the neighbourhood of Vares alone, where are located modern blast furnaces. Bosnia, relatively speaking, is the richest of all the Balkan States in iron-ore reserves, with the possible exception of Greece; the Bosnian deposits are also much more uniform in character and composition. Iron-ore has been mined on a small scale in Slovenia and Croatia, but their total resources would appear to be comparatively unimportant, while those of Dalmatia, Herzegovina and Slavonia are insignificant. Iron-ore occurs in numerous localities in Serbia, Serbian Macedonia and Montenegro. The report from which the above information is taken covers also a number of other minerals.

NOTICE OF MEETING.

THE INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' MEETING.—Monday, December 19, at 7 p.m. Paper, "Worm Gearing," by Mr. Cyril Poole, Graduate, of London. Chairman, Mr. L. A. Legros, O.B.E., Member of Council.

PIER FIRES IN THE UNITED STATES.—Once more a million or so has gone up in smoke in a shipping pier fire in New York Harbour. This is one way to modernise port facilities, but it is a pretty expensive one, says *Engineering News-Record*, N.Y. Nevertheless, the frequency of such fires in all the ports in the United States would lead an outsider to believe that there is a theory that the way to get new piers is to burn down the old ones, together with a respectable quantity of merchandise that necessarily is stored in such terminals. These frequent fires ought to be reduced, if not stopped altogether. There is nothing about a shipping pier that makes its fire hazards extraordinarily high. On the contrary, both in the matter of fire resistance and fire protection its problems are easy compared to most buildings. That there are so many destructive pier fires indicates a lack of proper interest and control on the part of those responsible, a too easy acquiescence in the existence of dangerous conditions and of insufficient structures.

PERSONAL.—We are informed that Messrs. Bostock and Bramley, of Netherton, Huddersfield, have entered into a combination with the old-established firm of Messrs. Joshua Buckton and Co., Limited, of Leeds. Messrs. Bostock and Bramley specialise on power transmission work, and we understand they will be responsible for designs, specifications, &c., for their speed transformers, gearing, &c., which will be manufactured by Messrs. Joshua Buckton and Co.—The Monometer Manufacturing Company (1918), Limited, inform us that a new company has been organised in France in order to manufacture and sell under a royalty basis all the Monometer productions. This company will have the sole selling rights for the whole of the French markets and French territories and the Belgian markets and Belgian territories; it is anticipated that owing to the cheaper cost of production the turnover will be larger than that for the British markets. Similar arrangements are being made for Holland, Scandinavia, Germany, Russia and Czecho-Slovakia.

THE MINERAL RESOURCES OF ALGERIA.—The exports of ore from Algeria during 1920 were the following, in metric tons: Iron, 1,111,438; copper, 601; lead, 12,804; zinc, 27,716; antimony, 2,966; phosphates, 334,704; superphosphates, 11,603. The largest producer of iron ore was the Mokta-el-Hadid Company, the output of this company being 533,720 tons. These figures are taken from a report on the economic and commercial situation in Algeria by Mr. J. K. V. Dible, the Acting British Consul-General at Algiers, recently issued by the Department of Overseas Trade. Four new concessions were granted to three different French companies during the last eighteen months, two for zinc and lead and one for lead and arsenic, these three concessions being in the Department of Constantine. The fourth concession, in the Department of Oran, was for oil, also granted to a French company, the area conceded being 1,005 hectares (2,840 acres) and the output about 3 tons per day; this same company owns another oil concession, also in the Department of Oran, the output of which amounted in 1920 to 609 tons. There is a coal mine at Kenadsa (Oran), close to the Moroccan frontier, worked by the State Railways, the output of which was 6,911 tons in 1920; also a lignite mine at Smendou (Constantine) the output of which was 1,796 tons.

ENGINEERING WORKS IN BRITISH MALAYA.—In placing the recently-floated Straits Settlements loan before the British public, the Crown Colony authorities laid emphasis upon the fact that the money was to be devoted to the completion of public works in the Straits and Federated Malay States, material for which would be supplied from the United Kingdom. Reproductive public works are being carried out as rapidly as material and labour can be obtained, also in the outlying Malay States of Kelantan, Kedah, Perlis and Johore on the lines so successfully followed in the Federated Malay States, and vast opportunities lie ahead in that region for trade development. Information recently received from Kedah states that a water supply scheme for the town of Sungei Patani is shortly to be undertaken, the water being brought by pipe line from Kedah Peak. The scheme is capable of extension to other localities in the neighbourhood as opportunity offers. The town of Kulim is also to be supplied with water by pipe line from hills in the neighbourhood. The pipes have been ordered from England, and the construction of the necessary dam is to be started forthwith. A contract has been let to a Penang firm for the supply of electric light to the towns of Alor Star (the capital of Kedah) and Sungei Patani. The Alor Star supply is expected to be in operation by April next, and at Sungei Patani the work is well in hand. The bridge to carry the main trunk road over the Muda River is almost completed. This bridge will render possible direct through communication by road from Siam, *via* Alor Star, Sungei Patani and Province Wellesley to Penang. Work is shortly to be commenced on a road bridge over the Muda River at Kuala Sidim, the approach roads for which are practically completed. The steel work has been ordered from England and was expected to arrive by the end of this year. The completion of this bridge will provide through communication between North and Central Kedah and Upper Perak, in the Federated Malay States.

THE NIDD VALLEY HYDRO-ELECTRIC INSTALLATION.

MESSRS. VICKERS, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 817.)

FIG. 3. DOWN-STREAM FACE OF ANGRAM DAM.

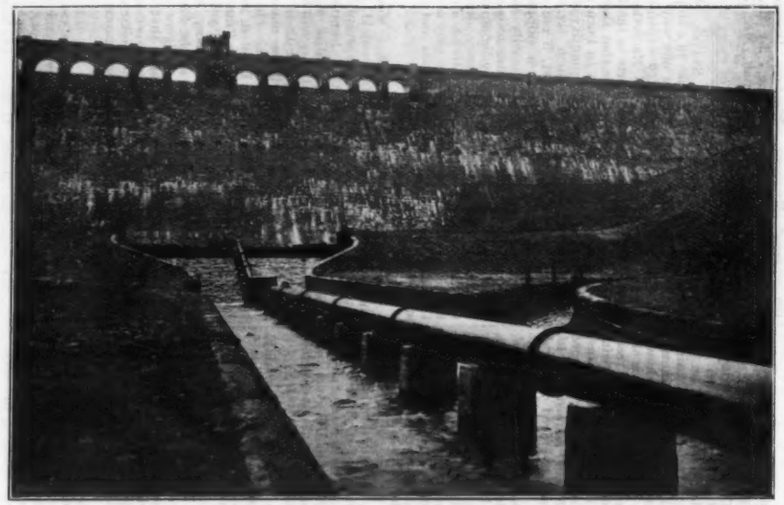


FIG. 4. UPPER END OF PIPE LINE.

FIG. 5. EXTERIOR OF POWER HOUSE.

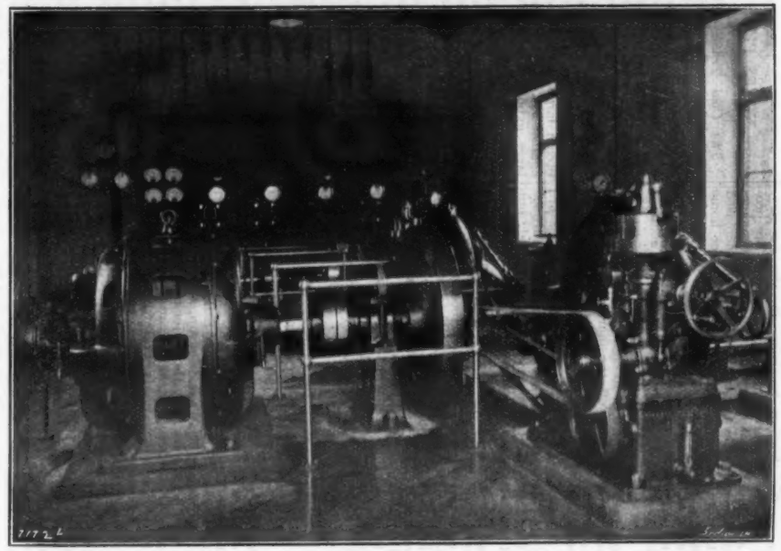


FIG. 6. INTERIOR OF POWER HOUSE.

THE NIDD VALLEY HYDRO-ELECTRIC INSTALLATION.

MESSRS. VICKERS LIMITED, ENGINEERS, LONDON.

(For Description, see Page 817.)

Fig. 7. SECTION A.A. (Fig. 8.)

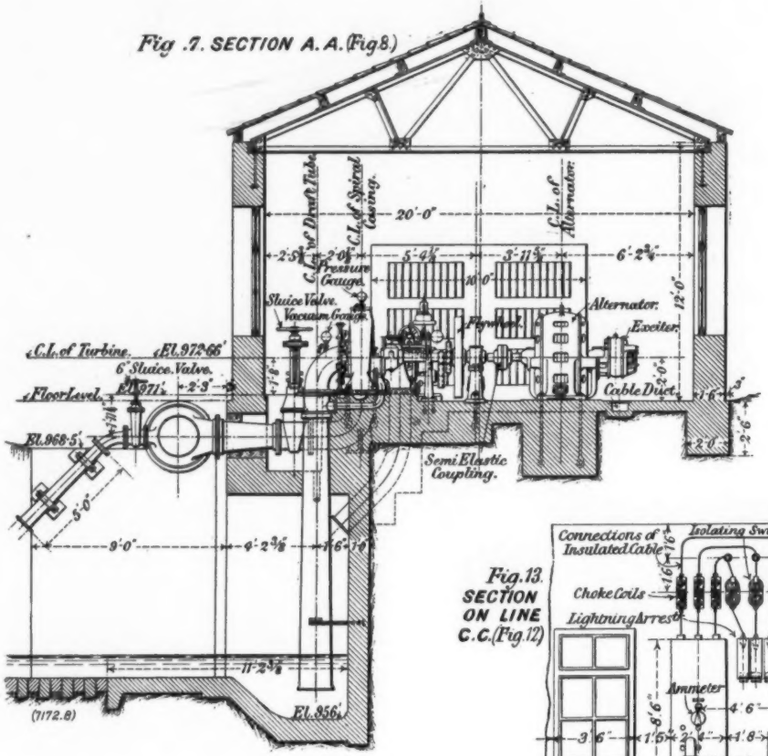


Fig. 9.

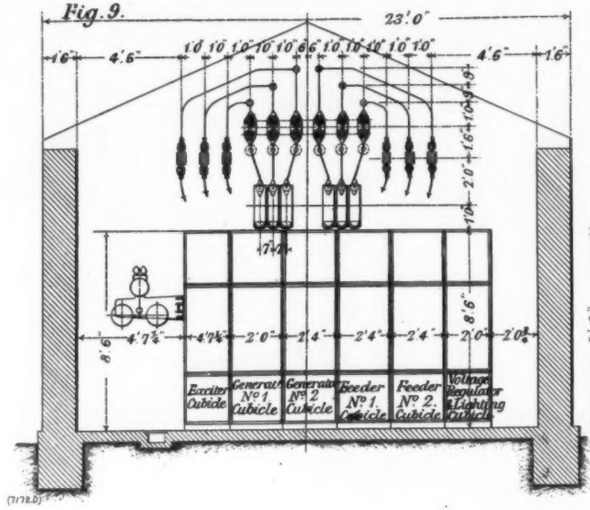


Fig. 10.

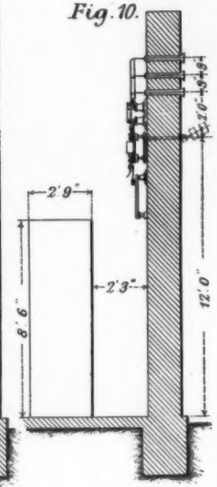


Fig. 13. SECTION ON LINE C.C. (Fig. 12)

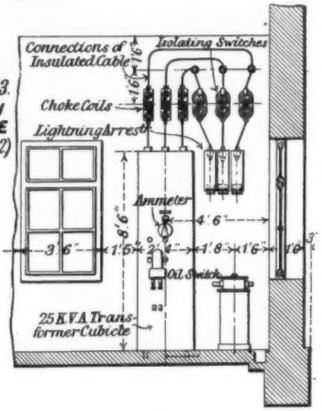


Fig. 11. SECTION ON LINE B.B. (Fig. 12.)

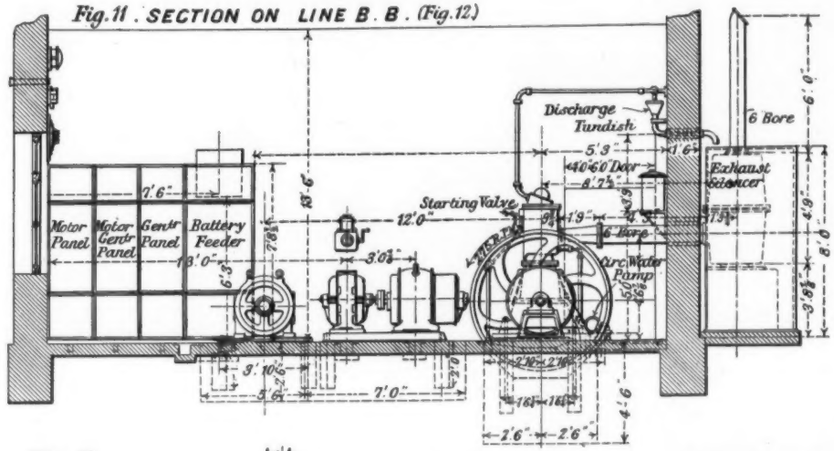


Fig. 8.

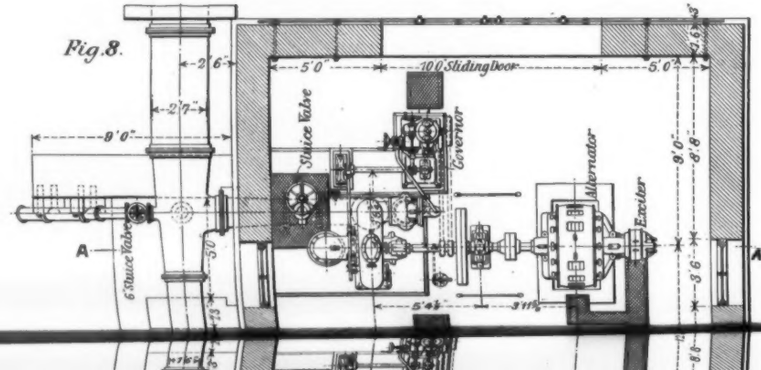
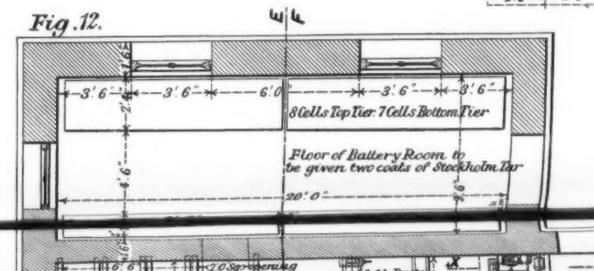
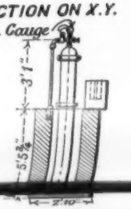
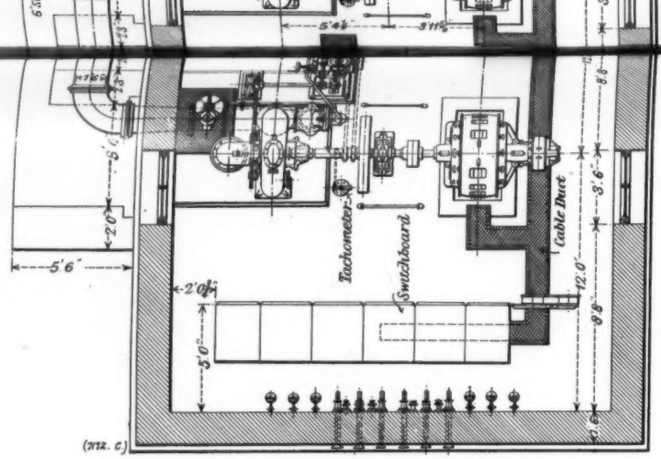


Fig. 12.



SECTION ON X.Y.





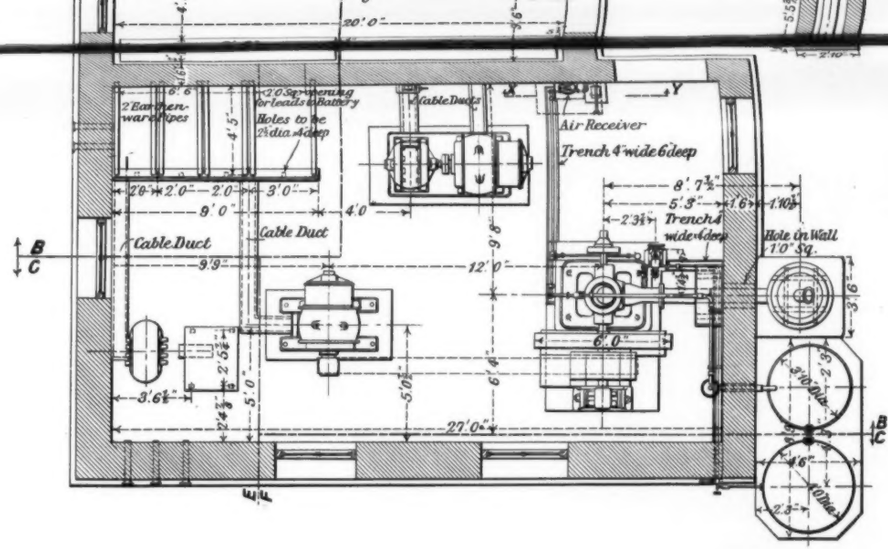


Fig. 14. SECTION E.E. (Fig. 12)

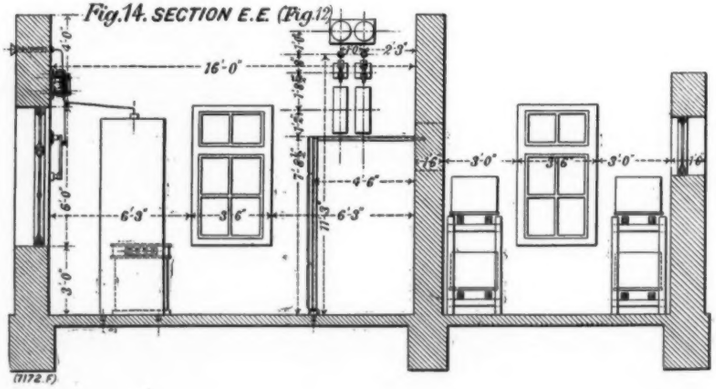


Fig. 15. SECTION F.F (Fig. 12)

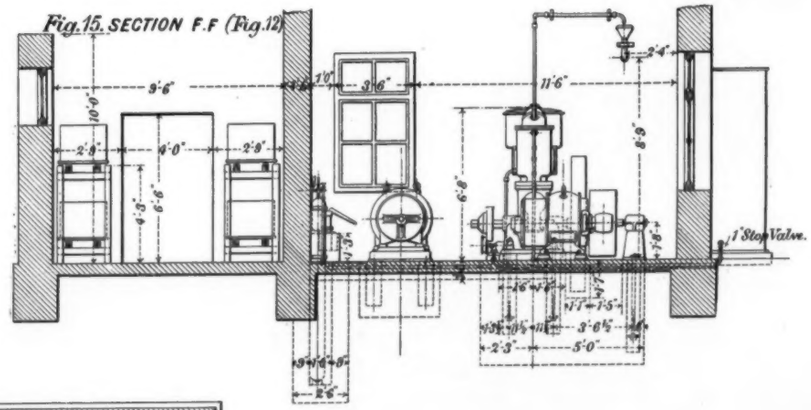


Fig. 16. HIGH TENSION SWITCHBOARD

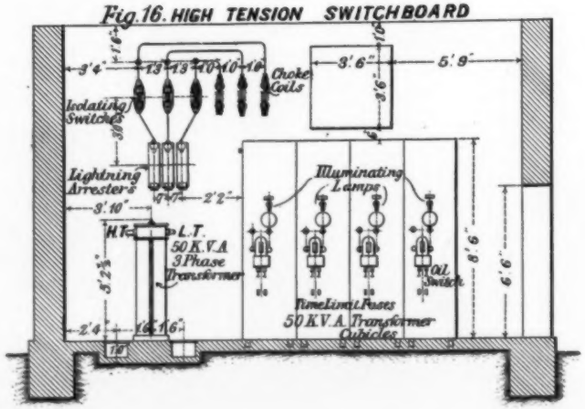


Fig. 17.

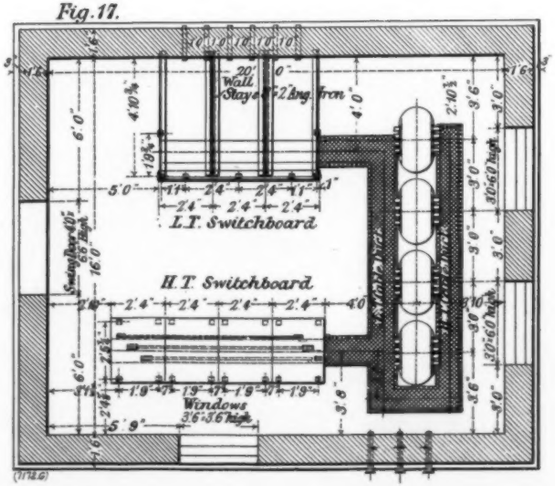
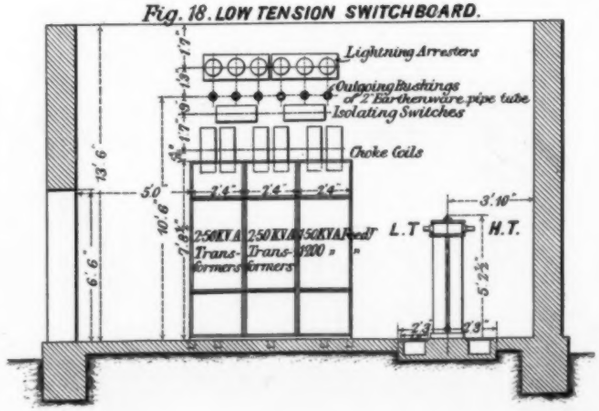


Fig. 18. LOW TENSION SWITCHBOARD.



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NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 823.

ENGINEERING.

FRIDAY, DECEMBER 16, 1921.

A NATIONAL PROVING HOUSE.

THE development of industry in this country has resulted in the formation of two great organisations, each concerned with different aspects of technical progress, and both having thoroughly practical objects in view. Twenty years ago, under the name of the Engineering Standards Committee, the British Engineering Standards Association commenced its task of securing agreement amongst manufacturers as to the dimensions of articles which ought to be interchangeable, and of defining a sufficient number of standard sizes to cover the range of commercial requirements. This work of the Association has been of incalculable benefit both to manufacturers and users, and it has been extended to cover the standardisation of the quality of materials employed in manufacture and the performance of certain kinds of plant. The great Government purchasing departments are now availing themselves of the services of the Association for the preparation of standard specifications of electrical plant and stores, and there is no doubt that in time all Government requirements of an engineering nature will be ordered in accordance with uniform standards, with advantage both to the services and to the taxpayer. It is very obvious that work of this kind involves considerable research before standards can be promulgated, especially where complex conditions are involved. Unless standards are to retard the progress of industry they must not only embody the best features of current practice but must be reconsidered from time to time as knowledge extends. Hence arises a need for accurate data and to provide this for industry generally the Department of Scientific and Industrial Research was constituted a few years ago. This, as is generally known, now controls the work of the National Physical Laboratory at Teddington, and supervises and assists approved research associations established in connection with the various industries.

With the Department of Scientific and Industrial Research to organise the scientific investigations upon which efficient manufacturing ultimately depends, and with the British Engineering Standards Association to embody the results as far as possible in acceptable standards of size and quality, it might be thought that the engineering industry was amply provided for in so far as standardisation is concerned. But recently there have been suggestions made in more than one quarter that some further action might be undertaken. The idea is that some responsible body should be constituted who would place their hall-mark upon all articles conforming in quality of material and in dimensions with the British standard specifications, so that such articles would possess a *cachet* recognised by the purchaser as a symbol of first-class quality. Manufacturers and consumers alike would have their interests protected, the former by their products being definitely distinguishable from cheap and spurious imitations, and the latter by the knowledge that by buying a hall-marked article they relieved themselves of all anxiety concerning its essential qualities. The work of insurance companies, moreover, would benefit by some such scheme, which would inevitably tend to bring about a high and uniform standard of quality for material or plant coming within the purview of the scheme.

Prominent among the advocates of a National Proving House which would hall-mark material of approved quality, is Mr. C. H. Wordingham, who both by his eminent position in the electrical profession and his long connection with the work of the Standards Association, is entitled to speak with authority on such a matter. He referred again to the question in his Presidential Address last Friday to the Junior Institution of Engineers and outlined roughly his ideas on the subject. The Proving House which he suggests would be an organisation controlled largely by manufacturers, but with sufficient representation of the great engineering institutions, advisory engineers, and purchasers' interests to ensure that the whole of its work should be on a high plane and above suspicion of bias. It would not receive financial assistance from the Government, nor would it be in any way under Government control, but it would enjoy the moral support of the Government by its formal recognition. Its duties would be primarily to carry out tests to ensure conformity with the specifications drawn up by the Standards Association and to administer the rules under which the registered mark of the association is applied. Without some such testing and governing body to safeguard the application of the mark, Mr. Wordingham fears that its introduction might do more harm than good, and its presence might be as misleading as the legend "Best Sheffield Steel" on cheap German made cutlery. Properly protected, however, and restricted to the first-class productions of manufacturers in the British Empire, it might become a hall-mark of quality throughout the world and constitute a powerful factor in the advancement of the British engineering industry.

Some such scheme as Mr. Wordingham outlined is undeniably attractive, and would be welcomed in principle by all who are interested in the quality of engineering work. But when one comes to consider it in detail the difficulties are seen to be serious. The analogy of the hall-mark on gold and silver ware does not carry us very far. Articles of the precious metals are small and portable, and the purity of the metal of which they are made is one of their most important features. Moreover, the tests for purity are simple and definite. The Goldsmith's Hall will certify by its mark that a gold or silver watch case comes up to a certain standard of purity, but it has never ventured to extend its work by any mark to certify that the hinges of the case are adequate or that the movement inside the case will keep time. The nearest analogy we have in engineering work, to the proposed National Hall-mark, is the trade mark or name plate of a reputable firm. This constitutes a kind of *prima facie* guarantee that the material and workmanship of the article are up to the standard maintained by the firm and that its performance will be satisfactory. Such a trade mark has a very definite commercial value, as it gives the customer a sense of security for which he is willing to pay an appropriate price. The underlying idea of the proposed national hall-mark is that it should convey a similar feeling of security, based on a knowledge that every part of the whole machine complied with a standard specification as to both quality of material, exactness of dimensions, and performance on a test-bed. It would confirm the claims of the best manufacturers, and would permit a new and unknown firm to take its place at once in the front rank if the quality of its productions justified this.

At first sight it might appear that the provision of a hall-mark to guarantee anything similar to the warranty conveyed by a trade-mark would be utterly impossible, if only by reason of the almost infinite number of factors which go to make up a satisfactory finished article. What, for instance, would justify the granting or withholding of a hall-mark in respect of a particular steam engine. Must the Proving House satisfy themselves that every casting, forging and stamping is of approved quality and dimensions, that bearing pressures and speeds are not excessive, that stresses in rods, shafts and levers are within specified limits, and so on? Even were this practicable, the goodness or otherwise of the engine will depend on the minutiæ of workmanship, the alignment of its parts, and the effectiveness of the provision for adjustment, lubrication and draining. In addition to these factors, the governing must be good, the steam-consumption within specified limits, the overload capacity adequate and the general behaviour of the engine satisfactory. Such considerations and more lie behind the nameplate of every well-known manufacturer, and for any National Proving House to guarantee satisfaction with regard to the points in question would require the maintenance of an army of inspectors in every works in the country.

It is therefore clear that no national hall-mark is

likely to supersede the value of the makers' nameplate, and it might even have an unfortunate effect in tempting the less scrupulous makers to shelve their responsibility on to the shoulders of the Proving House. But if the limits of its application, and its exact meaning are clearly understood it is quite possible that some kind of Hall-mark, might be adopted with advantage in the engineering trades. Marine boilers, crankshafts, &c., are now constructed to standard rules laid down by Lloyd's and the Board of Trade and the stamp of these authorities is, in effect, compulsory before any vessel can be insured or can be used for carrying passengers. Land boilers, in all their multifarious forms, are also inspected by various insurance companies, and stamped as fit for service under stated conditions. There is also, we understand, a movement on foot to create an organisation to inspect motor vehicles and to grade them in accordance with their merits of design and state of repair. If these things can be successfully carried out for the benefit of users, there should be no insuperable difficulty in setting up some such body as Mr. Wordingham contemplated, to place a stamp of approval on machinery generally. Their mark could hardly be extended to cover efficiency of operation, but would merely certify that the materials used were satisfactory of their kind, that the scantlings and dimensions of certain specified parts were adequate, and that the workmanship was up to a reasonable standard. Certain practices in manufacture might be prohibited altogether, and others made ineligible for machinery of the highest standard.

Whether a Hall-mark confined to the certification of such features as we have indicated would be worth the trouble and expense involved in the maintenance of a National Proving House is a question primarily for the large manufacturers' associations. A Hall-marked article would certainly receive preference at the hands of purchasers, even though the mark was fully understood only to cover a comparatively few of the qualities which a good machine of any kind should possess. The mark would rightly be refused to machinery constructed with odd-sized pipe-flanges, bastard screw threads and other defects which sooner or later cause so much annoyance when replacements are necessary. To this extent the manufacturers who refuse to adopt the standards approved by the trade generally, would be penalised and the purchaser protected. The whole subject is worth the careful consideration of engineers and manufacturers, for something of the kind suggested would appear to be the logical outcome of the work of the Standards Association, and even if no comprehensive scheme is possible in the near future, any steps towards the certification of machinery by a competent authority should make for industrial progress.

TRADE UNION BALLOTS.

It may be claimed by trade unions that the manner in which they conduct their ballots is a matter of purely domestic concern, but the general public are so often seriously affected by the result of the ballots that they may be excused for following with interest the cases (Brodie *v.* Bevan and Dunn *v.* Bevan) which were tried by Mr. Justice Sargant last week in which some members of the National Society of Operative Printers and Assistants challenged the validity of certain ballots of the members of the society.

The society being in need of increasing its funds, a ballot on the question of a general levy was taken in the beginning of May, 1921, but the result was adverse, by a narrow majority, to the proposed levy. A few weeks later, viz., on May 30, a second ballot was taken, and this time the majority of the votes were in favour of a levy. The plaintiffs maintained that the ballot was irregular, and refused to pay the contributions, although they were willing to pay their ordinary weekly contributions. The society apparently proposed either to refuse to accept the plaintiffs' subscriptions if they did not pay the levy, or else to apply the subscriptions towards payment of the levy, and the plaintiffs were in danger of being ultimately excluded from the society. The rules of the society, as interpreted by Mr. Justice Sargant, provided for the votes in the case of a national ballot being counted by scrutineers at the head office of the society; but the votes were actually counted by district or branch scrutineers who made a return of the votes to the head office. The plaintiffs maintained that this invalidated the ballot, and Mr. Justice Sargant upheld their contention. He thought the procedure adopted was not in conformity with the rules, and pointed out that the matter was of practical as well as technical importance, because the secrecy of the ballot was to a considerable extent stultified by the votes of each branch being counted locally. Another objection was taken to the ballot, viz., that the ballot papers had printed on them the words: "If you want to save the society you must vote in favour of these proposals." Mr. Justice Sargant said that in his view a statement on a ballot paper which was intended to influence the voter was objectionable, although there was no objection to a circular accompanying the ballot paper. He did not think that this would have sufficed to have invalidated the ballot, but it was not necessary for him to decide that point because the ballot was otherwise invalid.

A further ballot was also challenged. It was taken on August 8, and the rules of the society had been altered as a result of it. It was impugned because the ballot paper of each of the London members, who were about half the total membership, had been marked in pencil with the number of the member to whom it was issued, so that every ballot paper issued to the London members was identifiable. Mr. Justice Sargant held that the rules provided for ballots being taken under conditions of secrecy, and that the identification of the votes in this way had infringed the rules and invalidated this ballot also.

In addition to declarations regarding the invalidity of the ballots, the plaintiffs sought a declaration that the defendants were not entitled to refuse their weekly contributions or to allocate them to the levy, and it was maintained for the defence that the action was excluded by Section 4 of the Trade Union Act, 1871, which provided that nothing in the Act should enable any court to entertain any legal proceedings instituted with the object of directly enforcing any agreement for the payment by any person of any subscription or penalty to a trade union or any agreement for the application of the funds of a trade union to provide benefits to members. Mr. Justice Sargant held that the action was not struck at by the Statute, as he was not being asked to enforce an agreement for payment of subscriptions or the application of the funds, but merely to decide that the society could not insist on their members paying the levy as a condition of their remaining members. He decided that the ballots of May 30 and August 8 were not properly taken, and that the plaintiffs were not liable to pay the levies. The plaintiffs will have done good service to trade unionism and to the community in general if their action results, as seems probable, in trade union ballots being conducted in future under conditions which will ensure that their members may give their votes without fear and without reproach.

THE FUTURE OF BRITISH RAILWAYS.

The recent Railway Act, the unprecedented conditions of the high cost of labour, and the depressed state of trade, result in the railways of this country now being faced with problems which were formerly outside their range of vision. The extraordinary change is hard to realise, but there is no doubt that the companies are on the threshold of a new era, in which many of the matters they previously handled must be considered on an altogether new and vastly enlarged scale, and in quite a different perspective. In pre-war times we had excellent systems, on which, in view of the actual service given, the charges were reasonably low. In spite of the "settlements" arranged in those days by Mr. Lloyd George, labour remained comparatively cheap up till the time of the war, and such increased working expenses as resulted from the concessions were fairly well offset by improvements in working, co-operation between the companies, and so on. Those times, however, are now gone beyond recall, and even supposing the present depression to pass, and traffic to revive, the companies would still be faced, if continued on the present methods of working. with heavy labour costs, and with only heavy rates and charges to meet them.

It has been stated that, though the time has been short since the higher rates were introduced, the interval has already been long enough to show that these charges are now above the limit the traffic can bear. We are inclined to doubt that sufficient time has elapsed for any sure indication of this, for the reason that the recent months have been a period of acute depression and trade dislocation, and it is almost impossible to gather whether the traffic shrinkage has been due to this or to uneconomically heavy charges. Except for some summer traffic, the public has been for a good while now spending less than formerly, or at least postponing expenditure, which as regards the present amounts to much the same thing. This attitude not only tends to diminish passenger traffic, but also reduces freight traffic, and the railways suffer on both counts. This curtailed expenditure and consequent loss of traffic to the railways is primarily due to the general conviction that this is not a time for spending money in many of the ways which were enjoyed before the war, or even a year or so ago. At the same time the increased charges must go to increase the expense of putting goods upon the market, unless manufacturing costs are reduced a corresponding amount. We are to-day faced with the fact that our goods are too expensive for many customers abroad, and anything likely to add to cost of production at home still further reduces our chances of selling ahead. It would therefore be a national benefit if we could find some way of furnishing cheap transport, which, with the present trend of falling wages, might assist in reopening our trade channels, and thus help to restore in some measure the prosperity we all alike wish for.

From the point of view that it brought to a focus the many facts now affecting the railway situation, Sir George Paish's paper on the "Future of the British Railways," read before the Institute of Transport on Monday last, will doubtless prove useful. The author admittedly made no attempt to suggest how the systems were to be run, to win them back to a healthy condition, but he summed up the general effect of post-war changes and emphasised the need of radical departures from present practice. The whole position can be summarised in a few words. Whatever reductions there may be on the scales of wages it is most unlikely that they will fall to anything like the level of pre-war days—neither is it desirable that they should do so if it can be avoided economically. The money to meet these payments, and to allow a sufficient return on capital for the companies to be financially sound, must be forthcoming, but in the best interests of trade cannot be raised solely through increased charges. The alternative is improved working through consolidation.

As to how far it is possible to go in this direction opinions differ. Sir G. Paish does no more than suggest that the amalgamations now afoot should do much to make an improved state of affairs possible. Sir John Aspinall, on the other hand, pointed out in the discussion that even before the war, many companies had working pools and agreements by which they had been able to introduce economies, and these having once been brought about could not now be anticipated a second time. Sir John evidently thought that some of the expected economies are likely to prove fictitious. Sir Henry Thornton and Sir John Aspinall both discussed the scale of the new amalgamated groups compared with the old systems, and the former remarked upon the magnitude of the task with which the companies are now faced under the amalgamation proposals. As Sir Henry Thornton pointed out, a completely new point of view has to be adopted. There are problems of centralised policy and decentralisation of detail to be considered, which before were outside the field altogether. The creation of central headquarter staff has to be worked out on absolutely new lines, and the whole organisation has to be remodelled at short notice at the instance of the Government. A reference was made to the large

systems of the United States, but Sir Henry reminded members that in that country the big organisations have been the outcome of slow growth, during which the various component parties were absorbed by degrees, and the problems which arose in such evolutions could be dealt with gradually, instead of all culminating at once as they have now done here.

Not only are these vast problems of organisation and administration demanding the attention of our best men at the present time, but also a new perspective has to be adopted with regard to labour. The pre-war services of the railways were built up on lines which for their success were dependent upon cheap labour. Now labour is no longer cheap, and the old methods have to be reviewed in the light of this fact, and reforms in working adopted to meet the situation. We shall never revert to pre-war conditions, and the railways will have to educate their staffs to look at matters more from the point of view adopted in countries where labour has always been dear. Although conservative in many of their methods, the railways have shown themselves progressive in the services they offered. It is now necessary for them to reconsider all their methods of working in order to effect, now that they are again thrown on their own resources, the necessary changes to re-establish themselves on a sound footing. As the introduction of machinery has necessarily accompanied development in countries where labour is dear, it is probable that the general attitude towards this procedure will undergo some modification, and a more sincere effort be made to substitute mechanical appliances for expensive labour wherever possible.

With regard to working expenses Sir John Aspinall drew attention to the vast proportion of engine-miles spent in shunting small wagons, and spoke at length on the introduction of larger wagons to save expense in this direction. The moment, he pointed out, was opportune for action to be taken in this matter, as the Ministry of Transport Act conferred on the Minister the power of saying how many, and what kind of, traders wagons might be employed on the railways. The average number of traders wagons built per annum of late years has been very low compared with the normal output in pre-war times, and Sir John estimates that we are short to-day by at least 132,000 wagons of this class. If these wagons could be replaced by larger ones, especially for traffic such as that in export and bunker coal, an appreciable economy in shunting engine mileage would be introduced at once. Hence, Sir John hoped for a great change of policy in that direction and for the adoption of larger wagons.

On these points of economical train working it is interesting to note that Sir Henry Thornton believes it will be possible to attain to average train loads of 250 tons to 300 tons. To-day our average train load is about 130 tons, compared with an estimated average of about 65 tons twenty years ago. Less than forty years ago the average train load in the United States was 170 tons; to-day it is 750 tons, so that the progress made in that country has been far greater than we have accomplished here, though, if Sir Henry Thornton's figures and deductions are practicable, something of the same proportion, though not equal magnitude, should have been possible.

Since de-control the companies have adopted the bold policy of reinstating many of the pre-war services. Sir W. Acworth contributed to the discussion the suggestion that the railways had possibly given the public too great facilities and services in the past, and that, with a little education of the traders and others, their co-operation might be won for more economical working and cheaper rates. Now that competition by means of facilities, is largely eliminated, it ought to be possible by inducements to ship in larger quantities, or to be satisfied with less prompt delivery, to bring about economies which would result in cheapening transport to the benefit of the railways and nation alike. All these possible means of retrieving the situation will have to be considered, for it is essential to the country that the railways should be prosperous and re-established on sound financial lines.

THE STRUCTURE OF SOME GASEOUS MOLECULES.

THE dimensions of gaseous molecules can be deduced from viscosity measurements. As long, however, as the viscosity of a gas was supposed to be independent of the pressure, and proportional also to the square root of the absolute temperature, these deductions were of little value; for the temperature proportionality does not hold. About 10 years ago Sutherland and Chapman gave a new formula for what Professor A. O. Rankine, D.Sc., of the Imperial College of Science, calls the "mean collision area," which he writes $4A = 0{\cdot}4913C/\sqrt{2\,\gamma\,\eta\,(1+S/T)}$, where ϵ, C, and η are the density, mean molecular velocity and viscosity, γ is the number of molecules, T the absolute temperature, and S the Sutherland constant. The "mean collision area" A comes in in this way. If the molecules were, like the atoms of the inert gases, elastic spheres, the probability of a molecular collision, which determines the viscosity of a gas, would depend upon the radius of the sphere. But molecules will differ in their shapes, and then the probability of collisions between the molecules, sweeping through gases, will also depend upon their momentary orientation. Upon these considerations, and upon general modern views, Dr. Rankine, working in conjunction with Messrs. H. Harle and C. J. Smith, has based a very suggestive research which he outlined before the Faraday Society on the 13th inst.

It is now generally believed that different atoms differ by the numbers of their outer electrons surrounding the closed shells of eight electrons characteristic of the inert gases neon, argon, krypton, xenon. The mean collision areas A of these are respectively in square c.m. $\times 10^{-15}$: 0·417, 0·648, 0·757 0·915. It is further believed and supported by X-ray measurements that the atoms of consecutive elements such as argon, chlorine, sulphur, phosphorus, or carbon, nitrogen, oxygen, fluorine, have nearly the same sizes; for the last four the diameters are: 1·35, 1·30, 1·30, 1·35 Angström units. Now chlorine has one electron less than argon, and when it combines with hydrogen to form $H.Cl_1$ this electron is held in common by the two atoms. The HCl. molecule, Dr. Rankine suggests, might then form a big sphere (of argon size), from which a small hydrogen-nucleus sphere protrudes. For sulphuretted hydrogen H_2S we should have two hydrogen protuberances, in phosphorus trihydride PH_3 three; similarly three in ammonia NH_3, and four in methane $C.H_4$, but for these two latter compounds the reference gas is neon. Calculating now the A for these hydrides from viscosity measurements, Dr. Rankine finds that the A increases more rapidly than the number of the atoms. That is to say, if the mean A of argon is 1·00, those of HCl, H_2S, H_3P are 1·04, 1·19, 1·41, the increments being 0·04, 0·15, 0·22. There the repulsion between the different hydrogen nuclei enters as a factor. If we represent the molecules in cross-section D then HCl would be a large sphere with a small sphere half overlapping the larger; in H_2S the overlapping by the two nuclei would be smaller, in PH_3 still smaller. In other words, the protuberances due to the hydrogen nucleus would become larger as their number increases, and the mean collision areas A would hence grow at an increasing rate.

In support of these arguments Dr. Rankine referred to other relations. If we could add one positive charge to krypton we should obtain the atom rubidium, and if we could do the same to carbon, we should obtain nitrogen. Therefore CH_4 (methane) should bear the same relation to NH_4 (ammonium) as krypton bears to rubidium. Now the sizes of the molecule of CH_4 and the atom of krypton are found to be the same within 1 per cent., and Tutton's crystallographic measurements prove that in the sulphates of rubidium and of ammonium the volumes occupied by rubidium and ammonium are likewise the same within 1 per cent. There the analogy extends into the solid state. It is further known that the two gases CO_2 and N_2O, chemically entirely different, have many physical properties in common. Thus the results of estimates of molecular dimensions derived from viscosity measurements and from crystal measurements mutually confirm one another, and such confirmations do more to reconcile us with modern views on electronic structure and on the peculiar position occupied by the inert gases than mere arguments. Every new method of research is valuable, as Professor Porter, President of the Faraday Society, pointed out. So far Dr. Rankine has, owing to experimental difficulties, limited himself to hydrides.

BETTER OIL-PRODUCTION METHODS.

THE paper on "Better Production Methods," which Mr. A. Frank Dabell, M.I.Mech.E., brought before the Institution of Petroleum Technologists last Tuesday, may be regarded as a further contribution to the discussion on Mr. Beeby Thompson's paper on the "Elimination of Oil Waste," which the Institution had held last month and which we noticed in our issue of November 11. Mr. Dabell had taken part in that discussionn, and he now dealt with oil-production proper (subsequent to drilling) and with the means of improving the yield of wells apparently on the decline. Though a production diagram showing a steady rise for some weeks, a horizontal line for months, and then a falling and flattening line for a few years was considered an excellent graph, Mr. Dabell said, the well when declared exhausted would probably still retain 50 per cent., and possibly 90 per cent., of its oil in the sand. That statement was questioned by one speaker, who had found that a "gusher" had exhausted a certain area, new wells proving unproductive; but it was endorsed by Mr. Ibbett and others.

Mr. Dabell urged that of all the operations in the field the bringing of wells into production deserved the greatest care and skill. For during that period the area embraced for drainage was determined; that drainage was dependent upon the formation of channels radiating from the well, and the distance from the bore of the vanishing points of the smallest of these channel-veins determined the area of drainage. Ideal conditions governing perfect production seemed to exist in the limestone formations of Mexico. Where they did not exist, each cubic foot of gas should be made to perform its work in expelling oil, eroding the rock and forming canals. Mr. Gordon-Pitt, speaking during the discussion, wished to push that point further. He considered the first quarter of an hour after perforation the most important period; mistakes then made by ordinary drillers anxious to get on could not be redressed; a "gusher" always did harm. That the importance of that first quarter of an hour or more is understood, was pointed out by several speakers, who also remarked that, in order to give the gas a chance of acting as propellant before it escaped, there should be no drilling on an anticline. That condition, of course, if not easily observed in countries like Trinidad, where the geological formations are very irregular, and several of the speakers happened to come from Trinidad oilfields.

Mr. Dabell referred rather to geologically regular and well-studied fields. In such fields incoming oil should carry with it in suspension that quantity of eroded sand that could be removed with the liquid. When the sand entered too fast, the rate of exhaustion should be reduced, while the rate of exhaustion should be increased in the opposite case. When decline set in, an exhauster might be put on the producing well; but the favoured volatilisation of the light oils would then raise the viscosity of the remaining oil, and the practice was not to be recommended, unless the exhauster could establish effective communication with another well, when sucking air through the sand would stimulate the contained oil. The propellant, air or water, might also be introduced in distant wells; Dr. J. O. Lewis, of the United States Bureau of Mines, had compiled data upon the advantages of these propellants.

As regards air, Smith and Dunn force air into the producing sands under varying pressures through some of the wells (air wells) on a property, the oil being pumped in the usual way from the other wells. The air acts by direct pressure, by carrying vapours, and by going into solution in the oil and ultimately expanding. The tubing of an air well must be hermetic; the pressure to be applied is little

influenced by the depth, but it is related to the character of the sand, coarse porous sands requiring the lowest pressures. The air system is said to have been successful in 80 per cent. of the cases, and in 32 per cent. the output has for three years continued at 3½ times the former rate. The prejudice against the second propellant, water, is strong. But water is, after all, the natural propellant, and American experts like Carll, Huntley and Johnson consider the theory of the displacement of oil by water sound, but the practice is difficult except when reliable data as to underground condition are available. At Bradford, in Pennsylvania, water has been used successfully for twenty years. According to Lewis the rate of travel of the water, depending upon the porosity of the sand, its saturation, the presence of gas and the hydrostatic head, ranged from 10 ft. up to 200 ft. per month—not a rate likely to cause an emulsion of the oil, about which some speakers at the meeting were naturally anxious. But oil may be trapped by the water, of course, which frequently follows paths of lower density in opposition to gravity, and Mr. Dabell would in general prefer air to water, because the former does no harm to the oilfields.

The question of doing harm to neighbours by either air or water was not overlooked. Mr. Dabell thought that air, at any rate, could only favour neighbours as well, unless derricks were crowded as disgracefully as in Burmah. The damage done by water might extend over large areas, however; but general control of oilfields was not suggested. Mr. Dabell agreed with others that some waste of the more volatile, valuable products might have to be tolerated in the interests of the shareholders and a larger oil yield. With respect to the use of water Dr. Ormandy drew attention to a demonstration made by Dr. Fyleman last week in the Society of Chemical Industry. It is very difficult to remove oil from stones to which it adheres, even by hot water, but easy when the water is made alkaline. The questions are whether enough soda could be added to the water to be used for oil displacement, and what the refiners would say when having to deal with a more or less alkaline oil.

NOTES.

Water Supplies and Water Power in Great Britain.

In June, 1918, the President of the Board of Trade appointed a committee under the chairmanship of Sir John Snell, to examine and report upon the water power resources of the United Kingdom. This body, known as the Water Power Resources Committee, was enlarged in 1919 and instructed also to consider what steps should be taken to ensure that the water resources are properly conserved and fully and systematically used for all purposes. The inquiries concerning Ireland, were carried out by a sub-committee which has already reported, and the final report of the main committee has just been issued by the Board of Trade. The principal features of this report were explained by Dr. J. F. Crowley, one of the committee, to a meeting of representatives of the press invited yesterday to the Board of Trade. The evidence examined by the committee establishes a *prima facie* assumption that the water powers of Great Britain will permit of the economical development of 210,000 kw. on a 24-hour basis continually throughout the year. This, it should be noted, is an amount of electricity equal to no less than 40 per cent. of the total output of the 410 British public electricity stations operated by steam power for the year 1917–18, and its generation by steam power would involve the consumption of something like 3,000,000 tons of coal per annum. The water resources of Ireland are estimated at an additional continuous output of 113,000 kw. on a 24-hour basis. The committee recommend that adequate data should be collected with reference to all the practicable power developments so that the main facts with regard to each site may be accessible to persons interested. Excellent work of this kind has been carried out by the Dominion Government with reference to the water power resources of Canada. The practice of the Dominion Government in forbidding any partial or haphazard development which would be prejudicial to a subsequent complete utilisation should also be followed in this country. The committee suggest that either the Board of Trade or the Electricity Commissioners should be specifically charged with the duties of studying, supervising and promoting the development of water power, and that tidal power should be especially studied by a Technical Commission with particular reference to the Severn Estuary. With regard to water for purposes other than power, the committee recommend that a Water Commission should be appointed for England and Wales, to allocate and readjust the water resources in the best interests of the population, subject to Parliamentary sanction in cases of opposition. No corresponding recommendation is made as regards Scotland, as the abundance of water available in that country renders such a body unnecessary. The full report is published by His Majesty's Stationery Office at the price of 8s. net.

The Utilisation of Water Power.

In an interesting address to the Manchester Association of Engineers, delivered on the 9th inst., Sir Dugald Clerk drew attention anew to the fact that without ample supplies of power we should be unable to support anything like our present population. In the middle of the eighteenth century we numbered but 10,500,000, and even with modern systems of transport it is questionable whether we could as a non-manufacturing community, support more than about 20,000,000. From the census of production taken in 1906 it appeared that on the average each individual engaged in our manufacturing industries made use of about 1 h.p., or a total of about 10,500,000 in all. Of this total all but 117,907 h.p. was provided by coal or oil. Hence the enormous increases made of recent years in the cost of fuel threatens most seriously to handicap, and possibly destroy, our position as a manufacturing nation. Much, no doubt, can be done to economise fuel which has admittedly been somewhat extravagantly expended in the past, as is well shown by Sir Dugald Clerk's estimate that the coal consumption per horse-power-hour in this country has been no less than 3·9 lb. With regard to water power he quotes an estimate made by Professor A. H. Gibson, of Manchester, to the effect that the whole of our present requirements for power, if reduced to a 24-hour per day output, does not exceed 3·7 million. The water power available here is estimated by Sir Dugald Clerk as 1,750,000 h.p., and he holds accordingly that a considerable fraction of the existing demand for energy could be met by developing this asset. A few years back only 0·6 per cent. of our total motive power was obtained from water, but the conditions are now improving. The corresponding figure for the Continent is 27 per cent., and for the United States 24 per cent., and for the Overseas Dominions 33 per cent.

Mexico.

Very interesting information is contained in a report by Mr. Norman King, H.M. Consul-General in Mexico City, recently issued by the Department of Overseas Trade, and covering the whole of Mexico's resources and activities. Taking the products which will interest our readers the most, the report gives evidence that the country possesses great sources of mineral wealth, gold, silver, copper, lead, zinc, and various other metals being won in very large quantities. Coal also exists in different parts of Mexico; there are 700 beehive coke ovens and three retort coke-oven plants at the Sabinas coalfields, the capacity of the latter coke ovens being about 10,000 tons per month. The coal output was about 1,000,000 tons per annum before the revolution, but this figure has now fallen to about half. The railways use from 20,000 tons to 30,000 tons per month, as compared with 75,000 tons consumed before the revolution. All the coal produced is used in the country, the bulk of it being consumed on the plateau. Foreign coal is imported on the coast. The coal reserves in Mexico may be estimated at about 100,000,000 tons. Mexico, as is well known, is one of the principal mineral oil-producing countries in the world. The main oilfields are in the neighbourhood of Tampico. A conservative estimate places the amount to be spent in the present year, 1921, on pipe lines and reservoirs by the large companies alone at 45,000,000 United States dollars. Oil is known to exist on the West Coast of Mexico, and efforts to discover wells there are being actively made. The total production during 1920 may be taken as 162,000,000 barrels, of which 145,508,949 barrels, valued at 521,655,194 dols. were exported; besides this a quantity equal to 5,805,114 barrels was exported in bunkers, making a total of 151,314,063 barrels. Of this quantity, 78·08 per cent. went to the United States of America, 9·02 per cent. to South America, 4·27 per cent. to Cuba and the West Indies, 4·18 per cent. to Great Britain, 1·54 per cent. to Canada and 0·69 per cent. to Central America. In regard to labour, the report states that conditions are not entirely satisfactory, large numbers of workers having migrated to the United States, attracted by the higher wages which are paid there in most branches of employment. With reference to public works, little or nothing has been done recently, and the magnificent buildings begun under the former President Diaz, which were destined for the House of Congress and the National Theatre, remain unfinished and useless. Much needed harbour improvements at several seaports remain to be carried into execution. The railway service has been very much dislocated by the revolutionary conditions which have prevailed during the last ten years; losses in locomotives and rolling-stock have been exceedingly great, and it has been impossible to make them good owing partly to conditions in the country itself and partly to the difficulty of obtaining railway material during the Great War. It is greatly to be regretted that the Government has been unsettled for so many years past; had it not been for successive revolutions, Mexico would, given the numerous natural resources of the country, most probably now be in a greatly flourishing situation. In the chapter on Labour, the report refers to "agitators, usually foreigners"; from this we note that Mexico has not escaped the state of things which rules generally, her agitators being of the imported species, some of whom have probably become nationalised in order to give more plausibility to their oratory.

The Invention of the Aeroplane.

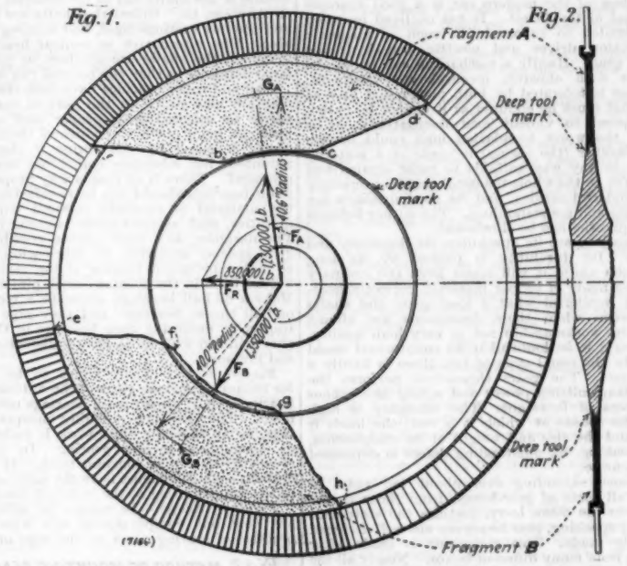
In our issue of October 28 last, on page 609, we referred to a paper read by Mr. Griffith Brewer before the Royal Aeronautical Society dealing with the trials of the 1903 Langley aeroplane made at the Curtiss Aviation Field, Hammonds port, N.Y., in 1914. It had been stated that these trials showed that the machine, in its original form, was capable of sustained free flight, whereas Mr. Brewer, for reasons fully stated in his paper, concluded that to render even a few short "hops" possible, certain fundamental modifications had to be made to the original design. The paper has since been printed in the December number of the *Aeronautical Journal*, together with the replies received from the persons mainly interested in the Hammondsport trials. Mr. Brewer's criticisms, it will be remembered, referred, amongst other points, to the strength of the wing trussing of the original Langley machine and to the overhanging leading edge of the planes, both of which features, he contended, had been materially modified in the Hammondsport trials. Dr. C. D. Walcott, the secretary of the Smithsonian Institute, in his reply, gives his reasons for maintaining that the wing trussing of the Langley machine was sufficiently strong for the purpose, and also explains that the Manly engine did not run as well in 1914 as it had done in the original trials. In the latter, he states, a thrust ranging from 450 lb. to 475 lb. was regularly obtained, whereas in the Hammondsport trials, the thrust could not be got to exceed 325 lb. The reason he gives for the omission of the overhanging leading edges is that it was done to save time and expense and not for the purpose of improving the design. In conclusion, Dr. Walcott remarks that on May 31, 1914, he saw the old Langley machine with the original engine giving only two-thirds of the original thrust, and with wings of approximately the original design, but much rougher in construction, get under way from rest and fly with a man and a load of 300 lb. of floats in excess of what the machine was designed to carry. Dr. A. F. Zahm's contentions, summarised, are that the short flights of the overloaded machine

in May and June, 1914, proved that the propulsive system of the 1903 machine was sufficiently powerful for sustained flight, and that the longer flights made later in the year proved that the control surfaces were sufficient to balance and steer the machine. He admits, however, that the 1914 flights proved nothing either for or against the adequacy of the general wing trussing, and points out that this could easily be decided by a special wing test. Mr. C. M. Manly, who carried out the experiments in 1903, contributes a long communication dealing with the causes for the failures of those experiments, maintaining that the experiment on October 7, 1903, failed because of an accident to the launching gear, and that unsuitable weather conditions were responsible for the second failure which occurred on December 8 of the same year. Mr. Glenn H. Curtiss, in a brief communication, maintains that the Langley flying machine of 1903 did fly in 1914 in its original condition and with its original motor and propellers, and with no alterations except the addition of floats and their necessary supports, weighing 350 lb. in all. This, we confess, we are unable to understand in view of the admissions in the other communications, and we may add that the communications, taken either individually or collectively, do not appear to us to dispose of Mr. Brewer's case. However, those of our readers who are sufficiently interested in the subject are recommended to read the original paper and the correspondence in full before drawing their own conclusions.

GERMAN REPARATIONS IN KIND.

There have been signs of considerable agitation in electrical circles during recent weeks over Sir Henry Strakosch's proposals that the German reparation payments should be made in the form of goods which are normally the subject of capital expenditure, and which would help the productive capacity of this country but which, at present, we cannot afford. The proposals mentioned, "great central electric power stations," "the electrification of the busiest railways," and "the improvement of the equipment of harbours." This agitation has now been officially recognised by the Institution of Electrical Engineers, and a letter on the subject of the proposed method of reparation has been addressed to the Prime Minister by the President of that body on behalf of the Council. The letter protests strongly against the proposals. It points out that if German electrical plant is to be accepted on account of reparation "its value must be debited to the undertakings using it. In no other way can such value be put to the credit of national indebtedness. There is, therefore, no good reason to suppose that the use of German plant obtained in that way would result in the users of it being able to give a cheaper service than with new equipment of British manufacture." The letter then goes on to urge "other considerations," and refers to present unemployment, stating that "Should it be decided to accept German machinery on a large scale, there is no doubt that a large additional amount of unemployment would immediately result." Such acceptance would also be a world-wide advertisement for German goods and "would fatally diminish the present prestige of British electrical goods." This letter brings together the various objections which have been raised to these proposals and states them in a concise way, but it is clear that it may itself be made the subject of criticism. The agitation in electrical circles has probably arisen from the fact that the original proposals concerned themselves with electrical apparatus, and from this point of view one cannot but have considerable sympathy with speakers for the electrical industry. On broad lines it is certain that it is an advantage to an individual, a corporation or a nation to get something for nothing. The only disadvantage such a gift may entail is that it may cause a local disturbance in industry. If an engineering firm was presented with all the forgings it required over a period of twelve months the matter would react unfavourably on the firm's forge, but the firm itself would be better, not worse, off, and as the forge was part of the firm and stood or fell with the firm, it, too, would ultimately be better off. If this country was presented with five million pounds worth of boots by Germany the matter would react unfavourably, for a time and for a time only, on British bootmakers, but the nation would be better off and not worse off. The wealth which would have gone to the manufacture of boots would be released for one or other of the very desirable things which we cannot now afford. No one, we imagine, would suggest that the German indemnity should be paid entirely in boots. The local trade disturbance it would cause would be too great, and similarly the electrical industry is very justified in protesting that electrical goods shall not be singled out as the exclusive medium. The idea that this is proposed is the cause of the present agitation. If we are ever to get the reparation payments out of Germany at all we will have to take much in goods, and all such goods as we obtain in that way will be a direct benefit to the nation and, as the greater includes the less, to every trade carried on by the nation. All that it is necessary to guard against is that no such great bulk of one commodity is accepted that local trade disturbance becomes serious. Finally, and incidentally, the electrical proposals with which we are concerned do not turn on the question of equipping a power station with British or German plant. They turn on the question of equipping it with German plant or not equipping it at all.

FAILURE OF A 30,000 KW. TURBINE AT PHILADELPHIA.



FAILURE OF A 30,000-KW. TURBINE AT PHILADELPHIA.

A VERY serious failure of a 30,000-kw. impulse turbine occurred at the Schuykill plant of the Philadelphia Electrical Company on September 3, 1921. It has been the practice at this station to make weekly a test of the run-away governor by speeding up the turbine until this governor came into action, which it was designed to do at 9 per cent. overspeed. The test had been completed, the steam shut off, and the turbine was slowing down, when one of the low-pressure wheels burst. There were two of these wheels, the turbine having a double flow exhaust. The consequence of the wheel failure was the complete wreck of the unit, the destruction of the generator being brought about by the fracture of the shaft. We reproduce from *Power* a sketch of the broken wheel. According to *Power*, this had a diameter of about 9 ft., by which apparently is meant the mean diameter of the blading. The normal speed of running was 1,500 r.p.m., so that the mean blade speed was about 700 ft. per second. The pieces broken out were each about 5 ft. long. The larger weighed 455 lb. and the smaller 415 lb. The centres of gravity of the two fragments are represented by G_A and G_B in Fig. 1, which also shows the centrifugal forces due to these pieces when the wheel was making 1,500 r.p.m. According to Professor H. F. Moore, of the University of Illinois, the appearance of the fractures leads to the conclusion that failure was due to fatigue. He found, in fact, that there was a certain area which had the appearance characteristic of "progressive failure," which was clearly demarcated from the rest of the fractured surface. He attributed the smash to disc vibration, though it would seem that this hypothesis is not free from difficulty, since if the wave were of a simple type the blading would have fouled the diaphragms before the bending stress became excessive. The surface of the wheel was somewhat roughly finished, and there was a deep tool mark at the radius indicated in Figs. 1 and 2. Professor Moore states that experiments at the University of Illinois lead to the conclusion that roughly-finished specimens may be 20 per cent. weaker against vibration than if given a well-finished surface. A metallurgical examination of the wheel has been made by Dr. G. L. Kelly, of Philadelphia, who reports that the heat treatment was not wholly satisfactory. His examination leads him to believe "that the wheel was probably made from cast steel in distinction to forged steel" and that "the original cast structure had not been effectively destroyed by the heat treatment." The appearances leading to this conclusion were, however, confined to regions near the rim, and did not extend to that portion of the wheel at which, according to Professor Moore's report, the fracture originated. The material appears to have been a 3½ per cent. nickel steel.

METALS IN THE BRITISH EMPIRE.—The Imperial Institute have issued a map of the world showing the chief sources of metals in the British Empire, with diagrams of production of the British Empire and the world for 1918. The map has been prepared under the direction of the Mineral Resources Committee of the Institute and gives at a glance a large amount of useful information on the subject. It can be obtained at the price of 5s. 6d net, plus 4d. for postage, from Messrs. George Philip and Son, Limited, 32, Fleet-street, E.C. 4.

FOUR-FIGURE LOGARITHMIC TABLE.—Messrs. Bowman and Murdoch, of 99, Shoe-lane, have issued, at the price of 3s. 6d., a four-figure logarithmic table, mounted on rollers, one line of figures being shown through a slit. The publishers claim that thus mounted, reference to the table is quicker than with the usual arrangement, and that as only one line of figures is visible at a time, there is less likelihood of mistakes. Interpolation is necessary, if the logarithm of a four-figure argument is required. The requisite proportional parts are printed to the right-hand side of the table.

SCHOLARSHIPS IN NAVAL ARCHITECTURE AND MARINE ENGINEERING.—We are informed that three scholarships will be offered in 1922 by the Institution of Naval Architects for competition in naval architecture and two in marine engineering. These will be as follows: Naval Architecture—Elgar scholarship (130*l.* per annum), Cammell Laird scholarship (150*l.* per annum), Armstrong scholarship (150*l.* per annum); Marine Engineering—Parsons scholarship (150*l.* per annum), John Brown scholarship (150*l.* per annum). These scholarships are tenable for three years and are open to British students and apprentices. The courses in connection with them may be taken at Glasgow University, the Armstrong College of Durham University, Liverpool University, Royal Naval College, Greenwich, or the City and Guilds (Engineering) College, London. Further particulars may be obtained from the Secretary of the Institution of Naval Architects, 5, Adelphi Terrace, London, W.C. 2.

NOTES ON MOTOR CAR GEAR-BOXES.*

By H. F. L. Orcutt.

The gear-box of the modern car is a good example of the survival of the fittest. It has outlived repeated creations intended to supersede it, such as magnetic clutches, friction drives and electric and hydraulic transmission gear. Hardly a mechanism can be named that receives such abusive, inconsiderate treatment, while its noise is tolerated by both maker and user as a nuisance that must be endured as it cannot be cured. It must respond to violent load fluctuations. It is mounted on the worst foundation man could devise. Its largest member (the casing) is made of a material which is not in any way suitable to resist strains and vibration. Yet on the whole the usual gear-box certainly does give wonderful service, and its good qualities are worth retaining and understanding. The author believes that its bad qualities can be eliminated.

Its good qualities are its durability, its simplicity and its efficiency. Its durability is proved by its long service and the abuse it will stand from the ordinary driver. When made of proper material, correctly heat-treated, it is wonderful what a load gears and shafts will carry, even when their dimensions are almost absurd and the workmanship not of very high quality. As to simplicity, it is doubtful if its counterpart could be named. In the usual type of box there is hardly a superfluous part. The gears themselves perform the functions of transmitting power and acting as clutches and distributors of lubricant. The efficiency is high considering the speeds at which it is run, the loads it must carry, and the size and weight of its components.

Broadly speaking, its outstanding defect is expressed in one word—noise.

An experience extending over about ten years of dealing with all sorts of gear-boxes, from those in the "light car" to the 6-ton lorry, justifies the statement that, generally speaking, gear-boxes are not well designed and are badly made. This statement is made after noting results from many different boxes. Nearly all the fundamental weaknesses of design are in the form of the box in which there is not sufficient rigidity and stability to support gears so that they can run quietly. The good workmanship by which accurate mounting is secured, is commonly wanting. Where a high-class article is desired, it is usually unnecessarily expensive to produce, due either to design or methods of manufacture employed, or both. While it remains a more or less standard mechanism, it has been subjected to less improvement than any other unit of the modern car. It seems a pity that some of the talent so lavishly devoted to engine work has not been applied to the many gear-box problems which are awaiting solution. The author believes that the stagnation of design in the gear-box is due primarily to two difficulties, first, that of producing exactly uniform gear teeth, and, secondly, that of mounting the gears so that they will run truly. These two mechanical defects exist in nearly every box, and obscure other weaknesses. Special experience shows that with the most perfect gears, accurately mounted, boxes will be noisy in running and will not be of uniform quality.

While it has been demonstrated that accurate gears are necessary for quiet running, it has also been proved that even with quiet-running gears satisfactory results are often quite impossible on account of defective design or workmanship on other components of the box.

Certain defects are common to all gear-boxes. They vary in degree, and it is doubtful if any maker of motor cars would say that he is perfectly satisfied with his transmission box.

These defects may be roughly summarised as follows :—

1. Design.
2. Workmanship.
3. Material.

Design.

Rigidity and Stability of Casings.—The design of gear mountings has been the subject of special attention from those who make use of gear-tooth transmission where comparatively high speeds and heavy loads are necessary. It has been found that unless specially designed bearings and adequately stiff shafts are used, gear troubles are common. Undoubtedly, in many designs of motor car gear-boxes the troubles experienced are due largely to lack of rigidity. The box itself is often shaved down to the smallest dimensions. In nearly all cars it is made of aluminium, a metal easily twisted, deflected, expanded or contracted. It is also well-known that aluminium has little elasticity and easily "sets" in almost any position into which it may be forced. Further, it has little stability and often changes shape to a degree that is enough to throw bearings out of line. It is doubtful if there is a motor car gear-box made with a casing which has the full theoretical rigidity called for by the loads passing through it.

Size of Shafts.—It is really astonishing (especially in some of the so-called "light cars") to note the design of the gear-box shafts. Even in some of the larger cars the tendency is to employ shafts of too small a section. The designer is influenced too much by the desire to reduce weight. Shafts certainly must be large enough so that they will not spring under load. Repeated experience shows that boxes with rigid shafts are quieter than those with small shafts, with gear teeth of the same quality in each case.

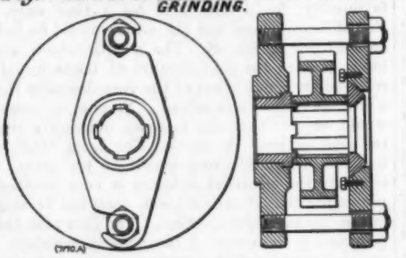
Design of Shaft Bearings.—The desire to reduce weight and retain simplicity has been carried to the extreme in nearly all gear-boxes. This remark applied especially to one feature of design, that is, the position and number of the shaft bearings. Theoretically, bearings should be so located as to support the shafts directly against the gears taking the load. In practice, with but rare exceptions, gears taking the heaviest loads are in the middle of the shafts and as far removed from the bearings as they can be. Unless the shafts are of large diameter and the box castings rigid, bad running is easily explainable. The alternative to central bearings is a design in which the shafts are as short as possible and of as large diameter as they can be, and run in a rigid casing.

Ball and roller bearings have been the subject of much research and study on the part of makers. They can easily be selected with proper load capacity. Roller bearings have much to commend them. They are not easily deflected by end thrust if shafts are properly mounted, but adequate end-thrust bearings should be provided. There is no reason why properly proportioned plain bearings should not be satisfactory, provided that the material is carefully selected with good wearing qualities, such as steel shafts running in bronze bushes. The designer, too, must foresee possible renewals, and give special attention to lubrication. The tendency to make the spigot bearing of the main shaft run in a bronze bush in the constant-mesh pinion shaft is correct. Makers of ball bearings advocate a more extensive use of ball thrust bearings, and they give sound advice in respect to mounting their bearings in the casing, so that they will run with no chance of distortion or undesirable end pressures.

Reverse Gears.—There seems to be no good reason for mounting reverse gears of the ordinary design on ball bearings, since proper plain bearings meet every requirement. They are also probably cheaper than ball bearings, as no specially close work is called for in making or assembling reverse gearing. In some gear-boxes reverse gears run in constant mesh. If quiet running is desired, such gears must have the same accuracy of tooth, finish and mounting as the so-called constant-mesh gears.

Forms of Shafts.—In respect to splined shafts, there are now but comparatively few who adhere to the practice of seating gears on the tops of the keys. The development of special hole-grinding machines in which the holes in gears can be finished at a comparatively low cost, and within fine limits, has helped to establish the practice, now common, of mounting the gears on the cylindrical surface between the keys of the splined shaft. Good practice should leave a considerable space between the top of the keys and the bottom of the splines in the gears; hence only rough-machining is necessary on the tops of the shaft keys. The bottom cylindrical surfaces and the sides of the keys of splined shafts are now so accurately machined that gears can be made to run just as truly on a four or six-splined shaft as if they were mounted on accurately-ground plain cylindrical shafts. The assembling of the sliding gears on the main shaft should be done with no fitting work whatever. Splined lay-shafts are also so accurately machined that fixed gears can be assembled on them with a light push fit with no fitting or hand work. When the proper order of machine operations is followed and correct limits are adhered to, the assembling of gears or splined shafts should be an unskilled operation. A suggested order of operations is given under the description of the process of gear-tooth grinding. Extreme accuracy in finish-machining splined shafts has been a necessary accompaniment to accurate gear-tooth finishing, as a gear with accurate tooth surfaces will not run quietly unless it runs truly. When a gear is mounted on the top of splines it is extremely difficult to finish the bottom of gear key-ways to a degree of accuracy that will ensure true running. When the gear is mounted on the cylindrical bottoms of a splined shaft, every mechanical operation necessary to true running can be done at a comparatively low cost, with no hand work and low assembling costs.

Fig. 1. METHOD OF MOUNTING GEARS FOR HOLE GRINDING.



Every possible precaution should be taken to fix details of design so as to reduce possible errors of workmanship to the minimum. Following this principle, it would seem that a four-splined shaft is the best form. In the main shaft with four splines, the circular portions between the keys give large wearing surfaces for the sliding gears, and the keys have ample driving strength for the heaviest loads. In the lay-shaft the surfaces give a good seating for the fixed gears. Tool equipment (especially the expensive broaches) is simplified if both lay-shaft and main shaft have the same diameter and keys. Cheap production costs are easier to maintain if the broaches are finished with small indexing errors and the widths of the broach splines are kept within small limits. As before mentioned, splined shafts should be of as large diameter as possible to assist rigidity. The square shaft is now employed by very few makers on account of the difficulties of mounting a gear accurately on such a shaft.

Design of Gears.—The requirements in the design of gears are pretty nearly the same for both sliding and fixed gears. The length of the hub of the sliding gear is often on the small side. The length of the bearing surface should not be much less than the radius of the gear. These gears should slide freely, and have sufficient bearing on the shaft so that the teeth will always mesh in correct alignment. Fixed gears should seat accurately on the lay-shaft and be locked up dead true. To prevent possible deflection, it is best to provide for finishing the ends of the hubs on lay-shaft gears true with the holes. If this is done, the gears on the lay-shaft can be mounted with practically the same clearance as those on the main shaft.

The following observations on gears are based on an experience of over eight years devoted wholly to gear-tooth grinding of transmission-box gears, after they are hardened. They are made with due humility, realising that the subject of gear-tooth forms is a big one, and much still has to be learned.

With but very few exceptions, makers of gear-boxes blame the gear-teeth for nearly all their transmission troubles. This is largely due to a lack of understanding of the extreme accuracy in gear-tooth forms that is necessary for quiet running, and the natural corollary that a badly mounted gear with perfect teeth cannot run with good tooth-contact. Designers and producers do not usually co-operate in taking every possible precaution that gears run dead true under load. They do not realise that the cheapest box is one in which quality above all should be safeguarded by good design, and that accurate machine work is the only cheap method of producing uniform results. Gears carefully mounted running at correct centre-distance, when quiet show contact over the whole working surface and straight across the teeth.

A 20-deg. pressure angle seems to meet general requirements. The pitch should not be too fine; there should be a sufficient number of teeth in all gears to avoid undercut and interference, and the gear-tooth section should be large enough to carry its load. To secure good wearing qualities, tooth widths should be ample; they are usually too narrow. It seems easier to secure good running qualities with the full depth tooth rather than with the stub tooth.

Without altering ratios to any appreciable extent, the variety of gears in a box could often be reduced. Two or more could be made with the same number of teeth, which would make savings in machine setting, in tooling and in inspection.

The making of so-called "cluster" gears, that is, two or more gears in one stamping, or the making of a gear integral with a shaft, are both of questionable practice. Careful investigation will show that economy and good results are in favour of each gear being a separate stamping, as making renewals cheaper and producing less scrap. In the case of a gear integral with a shaft, costs of material and machining are increased, and good heat-treatment is made difficult, since the correct treatment for the gear may be quite different from that required for the shaft.

Workmanship.

The workmanship necessary to produce a gear-box at a low cost that will run quietly and be of uniform quality is not commonly understood. Too little attention is given to accurate machine operations, and too much is left for the fitter, the assembler and the tester, while limits of errors and clearances are not properly fixed and inspection is not well organised. A well-designed gear-box should be produced with practically no hand work, and it should be assembled by unskilled labour. Dismantling, and re-assembling, "running in" of gears, or "stoning" teeth is uncalled for, and there should be no extraordinary scrap.

These statements apply to all gear-boxes, either the low-grade article where quiet running is not expected or the high-grade box where quiet, smooth running is demanded.

All mechanical operations on gear-box parts can be carried out to a limit of accuracy that should call for no corrections on the fitter's bench. These limits, as they apply to boxes where good running qualities are expected will be briefly stated.

Casings.—In the casing itself, the borings for the main and lay-shaft bearings should not have an alignment error exceeding 0·001 in. in 12 in. The centre distances should not have a variation exceeding 0·001 in. Where ball bearings are to be used, the limits of error in the sizes of the holes should be those laid down by the makers of the ball bearings, which, by the way, are usually not adhered to. Scraping out borings should be avoided. Forcing and hammering in bearings easily produces distortion in the soft metal housings, with all sorts of unsatisfactory and expensive results, and a variety of noises that defy classification. It would probably be well to have all casings inspected immediately preceding assembling.

Splined Shafts.—Splined shafts should be finish-machined with no error exceeding 0·001 in. in length, widths and indexing of keys, or on circular portions. The cylindrical parts can be easily ground to fit correctly in either bushes or ball races. It is hardly credible, but it is true, that many makers seem to have little appreciation of the necessity for careful accurate centreing of splined shafts. They do not seem to know that accurate grinding cannot be done when parts are revolved on inaccurate centres.

The following limits for grinding the holes in gears and on the circular surfaces of splined shafts give satisfactory results. They can be easily adhered to, and with proper inspection no fitting work should be necessary between the gear and the splined shafts.

The maximum clearance between the splines in the gears and the sides of the keys on the shafts depends on the accuracy of the broaching, and the accuracy with which the holes in the gears are ground in relation to the splines. As stated, the variation in size of the keys

* Paper read before the Institution of Automobile Engineers, December 15, 1921.

on shafts in length, thickness and indexing, can be kept within 0·001 in.

Holes in Sliding Gears and for Main Shafts from 1¼ In. to 2 In. Diameter.	In.
Limit for hole grinding	0·001
From minus 0·001 in. to standard.	
Limit for shaft grinding on circular surfaces	0·001
From minus 0·002 in. to minus 0·003 in.	
These limits give :—	
Maximum clearance of	0·003
Minimum clearance of	0·001

Holes in Fixed Gears and for Lay Shafts from 1¼ In. to 2 In. Diameter.	In.
Limit for hole grinding	0·001
From minus 0·001 in. to standard.	
Limit for shaft grinding on circular surfaces	0·001
From minus 0·001 in. to minus 0·002 in.	
These limits give :—	
Maximum clearance of	0·002
Minimum clearance of	0·000

To avoid fitting work, the maximum width of the shaft keys must be such that there will be no interference on the sides of the keys when the splines in the gears have their maximum errors. To assist in keeping these errors within workable limits, it is suggested that the splines in the gears be finished by a short specially made broach to be used for finishing only. This broach should remove the smallest possible amount of stock, and the pilot should fit the finish-ground hole in the gear. It should be finish-ground after hardening to standard size, with no errors in indexing or lengths and widths of keys exceeding 0·0005 in. This broach can of course only be used as suggested when the splines in gears are left soft.

The amount of play between the keys on the shafts and the splines in gears can easily be kept to less than 0·001 in. on both main and lay shafts. Alignment of holes in gears in relation to splines can be maintained if the fixture shown in Fig. 1 is used.

Gears.—The following notes refer to gears which have their teeth finished after hardening or heat-treating, and which either slide or are fixed on splined shafts, seating on the bottom cylindrical part of the shafts. The bottom of the splines in the gears should clear the top of shaft keys from 0·005 in. to 0·010 in. The top of the shaft key is only rough-turned to coarse limits. The sides of the keys on the shafts are ground to the degree of accuracy already mentioned.

The holes in the gears should be ground true with the splines, using a fixture similar to the one illustrated in Fig. 1, and though no care need be taken to finish the holes true with the teeth, the ends of the hubs of the gears should be finish-ground true with the holes. The variation in diameter of holes should not be more than 0·001 in.

To give good running qualities the mating gears should show a good hand-roll on fixed centres, and the teeth should show contact over the full working surface, from top to bottom of tooth and straight along the full width.

As it has been pretty well demonstrated that complete tooth contact is desirable, it naturally follows that the teeth of gears should be as nearly as possible of correct theoretical form—if an involute tooth, a pure involute—and the finish of the tooth surface should be as smooth as possible. Indexing errors should not exist; they probably do, however, to a certain extent occur in all gears, but unless so small as to be difficult to detect, noisy running will result.

Backlash.—The minimum backlash should be such that the gears when under duty will run freely when the box is made with the maximum allowable errors in all its components. Properly mounted gears with correct tooth forms run quietly without regard to backlash as long as they can run freely.

Practicable working backlash limits can vary from a minimum of 0·006 in. to a maximum of 0·010 in. Inspection should be made with mating gears mounted on close-fitting perfectly parallel fixed studs, set at exact centre-distances, with feelers inserted between the teeth which are in contact.

Eccentricity can be tolerated to a certain extent without bad results, but should be held to fine limits, say a maximum of 0·002 in.

Materials for Casings, Shafts and Gears.

Aluminium gear-box castings have one virtue; they are light in weight. But with this metal it is difficult to secure two essentials to good running, namely, stability and rigidity. It is a question whether the gear-box casing of the future will not be made of cast-iron, provided that the weight would not be increased too much. Covers and bushings certainly will be made of aluminium. For gears a 5 per cent. nickel case-hardening steel has been found most satisfactory. Gears made of this steel, with ample tooth surfaces and properly heat-treated, have been run for years in transmission boxes with no sign of "pitting" and showing only the slightest wear. For splined shafts a 0·15 per cent. carbon case-hardening steel meets the requirements.

Future Developments.

Will the gear-box of the more or less standard pattern as in the majority of cars, be the gear-box of the future? As at present made, it will probably not survive the exacting demands of the motorist, who is now accustomed to refinements in engine construction, good steering gear and smooth-working back axles. The author believes that it is possible to evolve a much better box than that now commonly made, making use of the principles that have been demonstrated by years of experience to be good. Broadly speaking, the weaknesses of the usual gear-box are twofold, the design and the workmanship. The design is one in which stability and rigidity are difficult to realise, two qualities which are indispensable to satisfactory running.

The author believes that experiments would demonstrate that in a gear-box of which the case is made of aluminium, success will be difficult. Probably a considerable amount of development work will be necessary before a casing will be evolved in which accurately finished and accurately mounted gears will give good results.

In respect to workmanship, it must be admitted that bad workmanship is the rule and not the exception. This should be corrected for several reasons. In the first place, the costs of production in nearly all boxes would be reduced, as accurate machine work combined with good inspection is very often cheaper than hand-work. The quality of most gear-boxes would be improved by increased accuracy in mechanical operations.

How many gear-box makers know exactly what they have done to a defective box which finally passes the test? Gears distorted by heat-treatment are "run in." Often the teeth are "stoned." Boxes are mounted in the chassis and given a road test, condemned, dismounted, and the gears perhaps "stoned" again or scrapped and replaced. Finally the box passes test. Who can say what has been done to cure the evils or exactly what was the original error? Scrap is made and costs are run up time after time, and the process is repeated, not in every car made, but in many, and in some cases many times on one car.

Uncertain costs are tolerated and quiet running on all speeds is usually given up as a hopeless task. The box finally passes the tester with no exact knowledge of what the original defects were, nor how they were remedied. Not infrequently a gear-box that is noisy in one chassis runs fairly well or even quietly in another. It seems reasonable to conclude from this fact that defects in other parts of the car made themselves manifest in the gear-box. This is undoubtedly the fact. Gear-box noises have been stopped when an imperfectly-balanced engine has been corrected, when couplings have been altered, and when propeller shafts have been increased in size or more firmly supported. If boxes were uniformly produced with all their components made within correctly specified limits, undoubtedly defects in other car units which are now often hidden in irregular gear-box workmanship would be more easily located.

Good design may be defeated by bad workmanship; indifferent design may be moderately successful backed by superior workmanship. Fully satisfactory results are impossible unless designer and producer co-operate, which they rarely do. Details of design should not be settled without consulting those responsible for production. Advice from the production staff should be freely volunteered to the engineering officials. Before a satisfactory box is produced much development work must be done, though the difficulties to be overcome are not formidable when compared with those which have been mastered either in the engine or the axle drive. Probably the standard type of gear-box in its broad principles is worth retaining.

The following are suggested as items which should receive special consideration in experimental or test work, with the object of evolving an improved design of gear-box :—

1. The selection of proper material for gears and shafts, with correct specifications of heat-treatment.
2. The design and material of the casing to be such as to give the rigidity and stability necessary to maintain good running conditions.
3. The determination of dimensions of components, including gear teeth, to meet full theoretical requirements of loads and speeds.
4. The correct specification of limits of accuracy of machine operations on all parts.
5. A careful study of the methods of production of parts so that designs lend themselves to machine operations by which low costs, accurate finish and correct mounting are possible.
6. The making of power tests of the box under load at all speeds, independently of chassis tests.
7. Tests in the chassis on the road to determine how running is affected by other units or by the method of mounting.

Gear-Tooth Requirements.

It will probably interest those who wish to give the subject of gear-box development special attention, to have as much information as possible respecting gear-tooth requirements. It is quite natural that there should be a wide divergence of opinion respecting a gear-tooth specification for transmission-box gears. Most motor car gears are either finished after heat-treatment with cutters which must necessarily rapidly wear out of truth, or they are hardened after machining and either "run in" or "stoned." Each of these processes results in the production of gears of which the teeth are not of uniform dimensions. It is difficult to form a definite opinion of an article in which the most important dimensions are of an irregular nature.

It is not generally known that gear-tooth forms where quietness, high speed, and high duty are called for, must have errors much less than those which are usually allowed in the finest cylindrical grinding. The errors must be so small that they are pretty well impossible to control commercially with any cutting tool except the grinding wheel, whether the teeth be soft or hard. Gear-tooth surfaces, being irregular curves, are difficult to measure, and the final test is made by running under load with theoretically correct mounting.

Gears which are of known uniformity and quiet running should pass the following inspection :—

1. Satisfactory hand-roll of mating gears at fixed centre-distances.
2. Power tests for noise at high speeds with mating gears accurately mounted at fixed standard centre-distances.
3. Backlash so that gears run freely without jamming. Backlash need not be to fine limits when tooth forms are correct.
4. Eccentricity must be within fine limits. It should not be more than 0·002 in. in any gear in the ordinary transmission-box.
5. Index errors (by which is meant the pitch spacing of the working faces) must be such that they cannot be detected under ordinary methods of inspection.
6. Tooth shapes must be as near standard as possible, showing on hand-roll or on power test with the mating gear a bearing over the whole working surfaces of the teeth.
7. The finish must be smooth. A roughly-finished tooth is not as quiet as a smooth one.

Gears in which the teeth meet the above specifications should run quietly, though the box in which they are mounted may be noisy, but if it is, the symptoms should not be mistaken for the disease.

(To be continued.)

Iron Smelting in Nelson Province, New Zealand.—H.M. Trade Commissioner in New Zealand has informed the Department of Overseas Trade that a blast furnace has been erected by the Onakaka Iron and Steel Company, a company formed in 1920 to manufacture iron and steel from the limonite iron ore found in the Onakaka (Nelson province) district of New Zealand. Coke, ore, and limestone are to be raised to the top of the furnace by a hydraulic lift. Sixteen beehive coke ovens are being built close by. The company anticipate that the industry will eventually employ some hundreds of men, and that the output of the plant will be 30 tons per day. New Zealand's requirements of foundry iron are said to be in the neighbourhood of 15,000 tons per annum, so that the company will not be able to supply the full requirements of the Dominion.

Motor Car Taxes in Italy.—We are informed that under a socialistic impulse, Italy decided some time ago upon such high taxes on privately-owned cars that the development of the motor car industry has been greatly restricted. A medium powered and popular car, such, for example, as the 10–15-h.p. Fiat, has to pay an annual horse-power tax of 48*l.* at nominal exchange. This firm's 15–20-h.p. model is taxed no less than 90*l.* a year, while each Fiat six-cylinder car in private service enriches the State Financial Department to the extent of 191*l.* per annum. After two years' experience the Italian authorities have realised that high taxes are not only seriously handicapping the motor movement, but that they are less remunerative to the State than the more moderate taxes in force before the war. In consequence, a technical commission presided over by the Under-Secretary of Finance has decided on a reduction of 50 per cent. on the motor taxes applied to small and medium-powered cars, as well as to motor cycles and motor-assisted bicycles. It is also proposed to abolish all taxes on electric cars for a period of five years, providing the vehicles are of Italian construction. There will be some reductions in the taxes on motor lorries, although these imposts have never been high compared with private cars. As an example, a 1½-ton Fiat van is at present taxed only 13*l.* per annum, while a private car with equal cylinder capacity has to pay over 200*l.* per annum to the State.

Adjustable Thermostat for the Range 0 to 100 Deg. C.—The thermostat which Dr. Samuel F. Lewis, F.I.C., and Miss F. M. Wood, B.Sc., exhibited at the Faraday Society on November 28, is exceptional as to accuracy and range. The thermostat body is of the Barnes-Gouy pattern and consists of a gantry-frame supporting the tank and the accessory parts. Two bridges crossing near the ends hold the clamps for the flasks, thermometers, heaters, stirrers, &c., which can easily be taken out, the tank being open at the top. The tank is a copper vessel, 24 in. by 14 in., 16 in. high. It is filled with water, at the top of which about 1 in. of glycerin floats to keep down evaporation. The water is heated both by gas flames underneath and by electric heaters consisting of nichrome wire wound on two uralite slabs. The thermo-regulator comprises a U-tube, partly filled with mercury and toluene, between the limbs of which a third tube extends upward. This tube narrows to a capillary and ends above in a cup of the needle-lubricator style. The needle is insulated and joined to one terminal of a relay, the other terminal being a contact on the capillary. The vertical movement of the needle is actuated by gearing connected with one of the two stirrers, which are propeller wheels mounted at the top of two vertical cylinders standing in the tank. The period of the vertical needle movement is two seconds; as the needle is withdrawn from the mercury the heating current is switched off by the relay, the electro-magnet of which is excited by the feeble current of the thermo-regulator. The heating current is branched off the ordinary 200-volt circuit through a lamp resistance. The U-tubes appear rather large and heavy, but a good deal of mercury is required in the thermo-regulator, because on cooling the apparatus from a high temperature, all the mercury might be sucked out of the capillary, and be replaced by air. The figures given by Dr. Lewis showed that the desired constancy within 0·01 deg. C. was fully realised.

CONTROL IN A RAILWAY IRON AND STEEL FOUNDRY.*

By G. N. Shawcross, M.B.E., M.I.Mech.E., Lancashire and Yorkshire Railway.

The chief point of importance in a modern works is the advance of the foundry, and locomotive works are not behind in this respect. Formerly it was the custom to tolerate the foundry as a necessary evil in comparison with other shops and to relegate it to a corner in the works. But the advent of the metallurgical engineer, of the moulding machine, and the air compressor with its accompanying pneumatic tools, have changed the one-time contempt into real interest, and it is now realised that cleanliness and system, lofty, well-lighted buildings, and overhead travelling cranes, are just as much part and parcel of a modern foundry as of an erecting shop and, further, that the money wisely spent on the initial start of a casting is amply justified by the returns due to less labour in the machine and assembling departments at a later stage. Frequent foundry references and really useful articles of late by the periodicals mark the same advance, and no engineer can afford to disregard how his castings are made.

The subject of control exercised in a foundry covers a wide field, entailing a first-hand knowledge of matters psychological, mechanical and metallurgical. Whether the production of castings is an art or a science is hardly for this paper to debate, but certainly the human side bulks largely. The moulder is the main factor in producing a casting successfully, his craftsmanship lies in the application of scientific principles, and it is not fully realised that any applied science in the foundry must have the help of the moulder.

Methods of placing the technical side within reach of the foundry craftsmen are shortly indicated at the end of the paper.

It is proposed to outline examples of the control of men, methods and materials in the well-known locomotive works of the Lancashire and Yorkshire Railway at Horwich, showing what output is produced and by what methods work is turned out; manufacturing system is not referred to in the scope of this paper beyond the fact that piece-work is adopted throughout.

This foundry produces castings of all descriptions, including railway chairs, iron and steel castings, malleable iron castings, and, lastly, steel ingots, the whole amounting to over 30,000 tons per annum, as follows, when fully employed :—

	Tons.
Iron castings	6,904
Cast-iron chairs	8,730
Malleable castings	146
Tropenas steel castings	2,512
Siemens' acid steel ingots	12,942
Total	31,234

* Address delivered before the Cambridge University Engineering Society, November 10, 1921.

Such an output valued at prices ruling in October, 1921, is worth approximately 500,000*l*. It is made in a shop 486 ft. by 111 ft., with six cupolas and two Siemens-Martin furnaces, one Tropenas converter located on the outside, as in Figs. 1 and 2. The steel castings are annealed, fettled and dressed in an adjoining shop, 138 ft. by 43 ft., the malleable castings being similarly treated in an adjoining space, 30 ft. by 43 ft. To produce such an output in a limited area calls for labour-aiding contrivances of many kinds, together with a plant run on a sound technical basis.

No other foundry in Great Britain produces the varied output above, the fact that this is done within the four walls of one shop gives considerable value to the paper in its description of output and equipment. By permission of Mr. George Hughes, C.B.E., chief mechanical engineer of the Lancashire and Yorkshire Railway, the author is enabled to show the workings of this foundry over which he has charge as foundry and steel works manager. Comparative figures of output are given for half-yearly periods of June, 1914, and December, 1920.

Tables I and II show both pre-war and post-war results. Valuable comparisons can thus be made, the pre-war period comprising a working week of 53 hours with two daily stops for meals, as against the post-war period of 47 hours with one meal hour daily. In both periods the foundry space and main equipment were exactly the same.

In comparing relative periods of foundry output the figure of man-hours to produce 1 ton of castings is given. Thus for iron castings the post-war and pre-war figures are 80·4 and 88 clock-hours respectively. For steel castings the figures are 130·7 and 129·6. The additional work caused by the conversion of molten iron into steel in the converter, and the fettling of the tougher steel castings, account for the greater number of hours for steel as against iron, after the factor of more repetition work in iron castings has been discounted.

Total hours, and not the moulder-hours, are stated on account of the uncertainty in the latter as to who is included, effect of boys, coremakers, &c. After all is said, foundry output is produced by foundry workers, the storekeeper and pattern attendant contributing to the whole when efficiently controlled. Also the total hours per ton is more readily comparable with other places when the ratio of hand to machine and plate moulding is known. A foundry moulding general millwright work cannot specialise like one on textile fittings or railway chairs, where thousands of castings are repeated.

In recent years the unstable conditions of rates of wages and shorter hours have made comparisons with pre-war records difficult, and foundry managers find that cost per ton is not nearly so illuminating as hours per ton, which, it is submitted, will be a standard of the future.

Probably no iron castings lend themselves to larger outputs and consequently to less hours of labour to produce, than cast-iron chairs. In this manufacture a large output may amount to 1,000 tons per week, which, consisting as it does of only a few varying patterns, may show so low a figure as 8 hours of labour to turn out 1 ton of castings.

The figure at Horwich for 200 tons weekly output is 9 hours to 10 hours per ton, a moulder and top rammer making 300 chairs per day. Such figures are not comparable with those for a general iron foundry, and only show what can be accomplished in specialised cases.

Data have been collected from a number of general iron foundries, and Table III tabulates figures of pre-war and post-war practice which only too graphically tell their own tale, namely, that the shorter working week now in vogue, together with post-war temperament of human nature, make serious problems for the British foundry manager to cope with.

Efficient management in supply services and methods of control in materials are essential, but of larger effect is the effort in the manufacturing system which every

Table I.—Total Hours Worked in Iron Foundry During the Half-Years Ended June, 1914, and December, 1920.

—	June, 1914.		December, 1920.	
	Ordinary Time.	Overtime.	Ordinary Time.	Overtime.
Moulders	58,785	1,097	66,586	585
Coremakers	20,710	1,729	24,625	631
Apprentices	49,132	839	38,738	—
Miscellaneous	114,867	12,166	108,936	21,231
	243,494	15,831	238,885	22,447

Number of Hours to make 1 Ton, 1914.		Number of Hours to make 1 Ton, 1920.		Output, Tons, June 30, 1914.	Output, Tons, 1920.
Per Total of All Labour.	For Trades and Apprentices only.	Per Total of All Labour.	For Trades and Apprentices only.		
hours 88·02	hours 44·9	hours 80·43	hours 40·37	2,046	3,249

Table II.—Total Hours Worked in Steel Foundry During the Half-Years Ended June, 1914, and December, 1920.

—	June, 1914.		December, 1920.	
	Ordinary Time.	Overtime.	Ordinary Time.	Overtime.
Moulders	17,463	1,066	16,769	1,845
Coremakers	1,518	345	3,846	138
Apprentices	5,067	15	1,750	—
Miscellaneous	59,798	7,260	59,363	13,824
	83,646	8,686	81,728	15,807

Number of Hours to make 1 Ton, 1914.		Number of Hours to make 1 Ton, 1920.		Output, Tons, June 30, 1914.	Output, Tons, 1920.
Per Total of All Labour.	For Trades and Apprentices only.	Per Total of All Labour.	For Trades and Apprentices only.		
hours 129·67	hours 35·49	hours 130·7	hours 32·63	712	746

Table III.—*Total Hours per Ton of Castings.*

Foundry No.	Makers.	Per Worker per 53 Hours in 1914.	Per Worker per 47 Hours in 1919.
		hours per ton.	hours per ton.
1	General millwrights and heavy castings	—	260·0
2	Heavy engineering castings, 50 per cent. dry sand moulds	220·2	221·7
3	Large engineering castings, 50 per cent. dry sand moulds	173·9	208·9
4	Tested boiler fittings, 50 per cent. M/c. moulded.. ..	124·4	147·8
5	Textile castings—day work ..	117·0	146·0
6	M/c. tool castings on day work	111·6	140·0
7	Textile machines	92·2	140·0
8	Jobbing work for M/c. tools, machine moulding introduced	151·4	94·0
9	Gen. casts., 90 per cent. plate patterns	—	78·3
10	Railway wagon axle-boxes, brake blocks, 80 per cent. M/c. moulded	—	45·0

Summary of Men Employed in Iron Foundry, on June 30, 1914, and December 31, 1920.

Grades of Men on Books.	June, 1914.	December, 1920.
Moulders	30	34
Plate moulders	17	9
Machine moulders	4	5
Coremakers	21	20
Furnacemen	1	4
Dressers	6	10
Boys	4	3
Casters	7	4
Stationary engineman	1	1
Fitters	5	3
Box fitters	1	2
Boys and apprentices	35	34
Top rammers	3	4
Cupola men	3	2
Labourers	41	50
Boy labourers	2	2
Coke wheelers	1	1
Sand mixers	1	2
Scalesmen	3	4
Rattlerman	1	1
Storekeeper	1	1
Material inspector	1	1
Ladle dauber	1	1
Emery wheel boys	3	3
Oilers	1	1
Boy driller	1	—
Yard man	1	1
Ladleman	1	1
Cranemen	4	3
Hoistman	—	1
	201	208

Summary of Men Employed in Steel Foundry, on June 30, 1914, and December 31, 1920.

Grades of Men on Books.	June, 1914.	December, 1920.
Moulders	11	13
Machine moulders	3	2
Plate moulders	1	2
Coremakers	1	4
Cupola furnacemen	4	4
Dressers	15	12
Boy dressers	2	4
Sawyers	5	2
Fitters	1	1
Ladlemen	2	1
Cranemen	2	2
Driller	1	1
Boys	5	3
Top rammer	1	1
Runner rammer	1	1
Scalesmen	2	2
Oiler	1	1
Slingers	2	2
Labourers	11	18
Pig wheelers	—	1
Electric welder	—	1
Casters	—	3
	71	81

LANCASHIRE AND YORKSHIRE RAILWAY IRON AND STEEL FOUNDRY AT HORWICH.

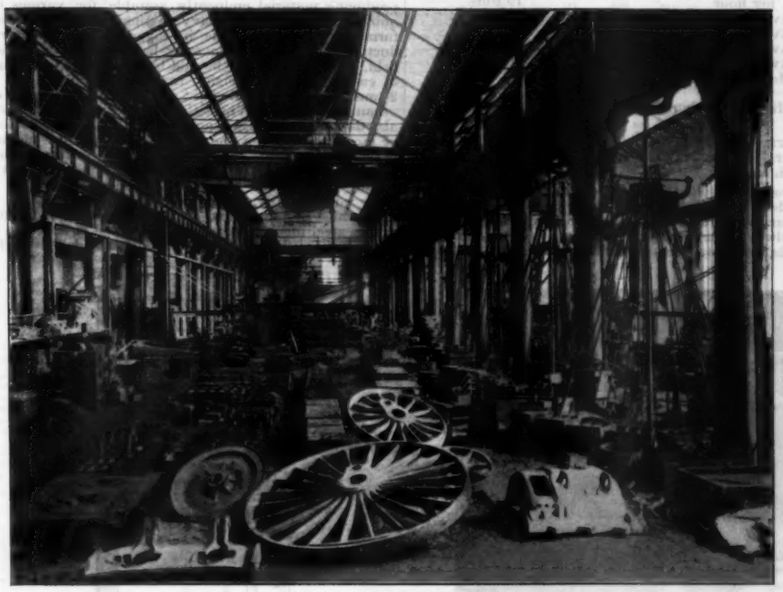


FIG. 1.

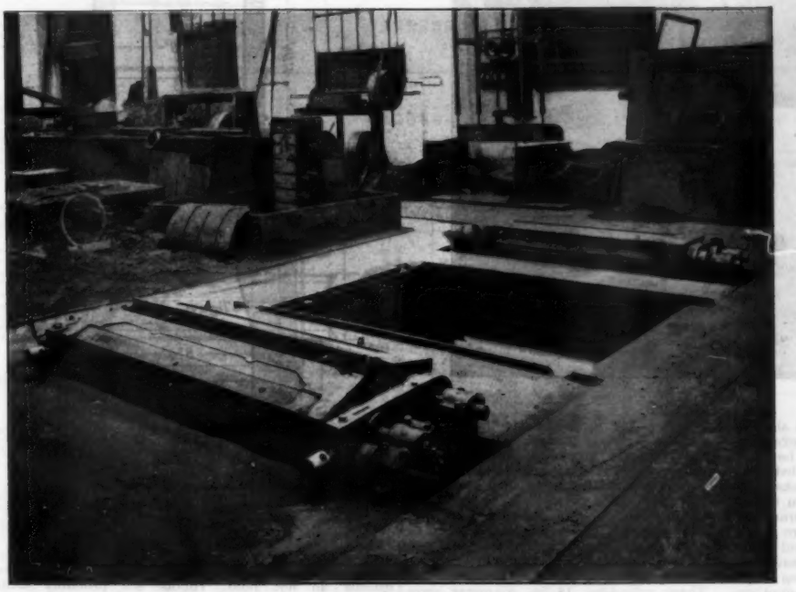
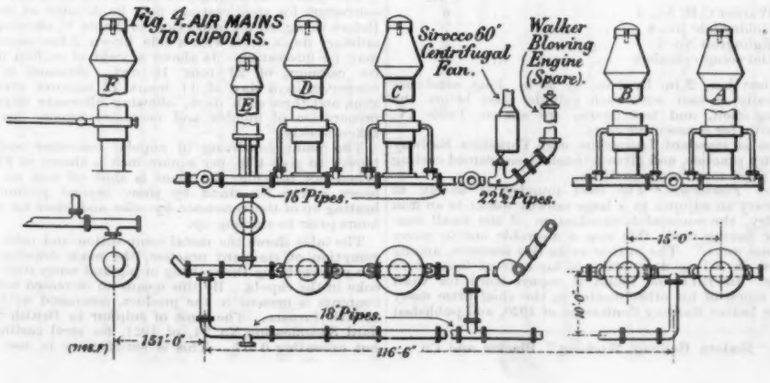


FIG. 2.



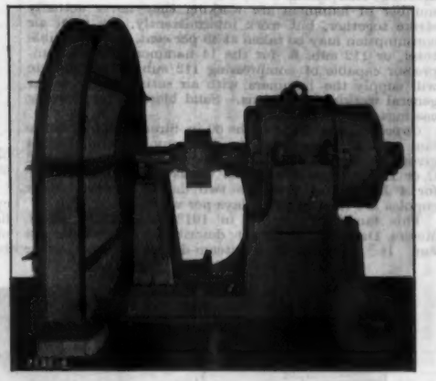


FIG. 3.

worker must exert for his own team and his own country. Castings are made in the following proportions :—

Iron Castings.

	Per Cent.
Hand moulding—chimneys, cylinders, superheater headers	45
Plate moulding—brake blocks and general	31
Machine moulding—C. and W. axle-boxes, fire-bars, brake blocks and general ...	24

Steel Castings.

Hand moulding	50
Plate moulding	12
Machine moulding—wheel centres, motion plates	38

Chair Castings.

Plate moulding—for sand and chilled castings and cores	100

A foundry engaged upon locomotive work and its accessories has to some extent an opportunity of specialising its equipment for certain classes of work which are standard parts. Though types of engines may differ, there are many instances worth noting where repetition work enables quick production to be achieved by the use of moulding machines or plate moulding. Twenty-six moulding machines are in use for sand and chilled castings, and cores, &c.

Various mechanical devices or "gadgets" are also contrived to meet some local requirement or minimise laborious work, as, for instance, hydraulic bucket lift to cupola, turn-tables for moulding machines, 55 ft. jib crane and magnetic tup for scrap breaking, gyratory riddles, &c. The foundry needs the best brains in its service, and there is unlimited scope to those who love it.

Services of Power.—Power is available in the form of :—

Electrical energy.
Producer gas.
Compressed air.
Air blast.
Steam.
Hydraulic pressure.
Town's water.
Waste heat and exhaust steam.

All these are utilised and need control to avoid waste. Table IV indicates the form the control takes and the instruments in use. Card records of repairs to compressors, fans and motors are necessary, whilst for automatic recording pressures of steam and air, the Simmance recorder is simple and requires little attention. Waste heat from heating furnaces is used for drying cores, and exhaust steam is similarly treated for blast saturation at the gas producers.

Air Compressors.—Compressed air, at 80-lb. pressure, is supplied by one Alley and MacLellan "Sentinel" air compressor, giving an output of 200 cub. ft. of free air per minute, at 276 r.p.m., and 280 cub. ft. at 346 r.p.m.; when running at the latter speed the motor power required is 50 h.p.

The compressor is direct-coupled to a 50-h.p. B.T.H. motor in place of being gear driven, thereby saving a considerable amount of power without any upkeep charges in the way of replacing pinions and gear wheels, and the noise of running is practically eliminated. It is used for working the Mumford and Tabor jarr-moulding machines, air hoists for auxiliary lifts, fettlers' chipping hammers, cleaning of moulds and core blacking.

Pneumatic hammers are indispensable; without them the area for fettling would require enlarging considerably. The steel fettling shop is equipped with fourteen Keller hammers, in constant use by all the dressers for cleaning sand and cutting fins off castings. There are many kinds, but the one found most suitable for foundry work is the Keller size No. IX. This hammer has a stroke of 1¾ in., piston diameter 1¼ in., is fitted with one cylinder, and gives 3,000 blows per minute. It weighs

12 lb., and has an air consumption of 20 cub. ft. of air per minute when working continuously for 1 minute.

Taking into account the time taken in lifting a casting on to the bench, fixing and putting it down again after dressing, sharpening of chisels, &c., also that where a number of hammers are working they never actually strike together, but work intermittently, the total air consumption may be taken at 40 per cent. of the possible total, or 112 cub. ft. for the 14 hammers, thus a compressor capable of compressing 112 cub. ft. per minute will supply the hammers with air satisfactorily under general working conditions. Sand blasting for cleaning castings is not used.

Cupolas.—Fig. 3 shows the 60-in. Sirocco high-pressure fan supplying air blast to the cupolas, and Fig. 4 gives the air pipe line. Of these cupolas A or B and C or D are worked daily, E works daily on malleable for 4 hours and F works two days per week. Four cupolas are thus run two days per week.

This fan was installed in 1912 when the makers, Messrs. Davidson of Belfast, described it as their largest fan. It supplanted a steam-driven three-cylinder

Fig. 5.

blower, and a No. 4 Root's steam blower, both of which have been retained as possible reserves, though seldom used, the latter being called upon in case a single cupola only is wanted to work. A second No. 4 Roots blower to drive cupola F has been dispensed with.

At the time of installation there were some doubts as to whether a high-pressure fan would alone do all the work, but nine years' service has proved it to be satisfactory in every way, saving both in power and attention costs. The only initial trouble was a slight "surging" effect of blast pressure at 26-in. w.p., which was overcome by placing a cast-iron pressure chamber, 3 ft. 6 in. by 7 ft. deep, in the pipe line under the fan, and by adjusting the position of the motor brushes 1½ in. out of their original position on the commutator.

A day's run of the fan is appended, and for information the specification to which the order was placed was: 60-in. Sirocco high-pressure fan direct coupled to one 120 b.h.p. shunt wound variable-speed motor, with commutating poles, by the British Westinghouse Company, to run at 800 r.p.m. to 1,150 r.p.m., with 250 volt C.C., including protected type, starting and speed-regulating panels, main switches and fuses, starter and regulator. Temperature rise of motor not to exceed 85 deg. F. The guarantee was to melt 17 tons of iron per hour, for a consecutive period of 8 hours in any of the cupolas shown in Fig. 4.

Record of Four Cupolas Driven by 120-h.p. Fan by Messrs. Davidson, of Belfast

	Ft.	In.		Melted. Tons.	Cwt.
A. Cupola	3	6	internal diameter...	58	0
C. Cupola	3	6	internal diameter...	43	0
E. Cupola	2	6	internal diameter...	1	3
F. Cupola	3	0	internal diameter (equal to *) ...	48	0

* F. melts 50 per cent. hematite pig-iron and 50 per cent. steel scrap.

Total iron melted by fan (fan worked 9 hours 45 minutes) = 150 tons 3 cwt., less 2 tons, melted by steam blower in meal hour.

Average amount of metal melted per hour	15 tons.
Average amount of current used	208·8 amps.
Average voltage	250
Average amount of air pressure	25·2 in. water.
Average speed of fan	1,012 r.p.m.
Maximum horse-power developed	84 h.p.
Minimum horse-power developed	53·5 h.p.

Note.—Cupola F was blown in meal hour by steam blower. Cupola A, C, E had their valves shut during meal hour.

Locomotive Cylinders.—The production of locomotive cylinders calls for skill of a high degree. If cast-iron fire-bars and brake blocks represent the cheaper quality of railway foundry work, certainly cylinders with twin barrels, intricate cores for steam valves and passages, and shaped to form a saddle for locomotive boilers, are an example of the highest grade of work. They require to be machined practically all over, bored, planed, drilled and tapped—without showing defects of porosity, cracks or shortness of metal, and lastly they must conform to tests of the material.

Granted the skill in coremaking, moulding and casting, there is a requisite composition of pig-iron and scrap to blend in order to produce a casting to which tensile and transverse tests may be applied. An example of this is given in producing cylinders at Horwich for main line locomotives. These cylinders, 18 in. diameter twin barrels, with circular piston valve chambers, weigh 2¼ tons each, and are cast of the following mixture:—

	Cwt.
Warner C.B. No. 5	6
Goldendale No. 6	7
Eglington No. 3	2
Old scrap cylinders	5

A test bar, 2 in. by 1 in. by 36 in. long, sand-cast vertically, is cast with each cylinder just before the casting itself, and test figures are shown, Table IV, opposite, for consecutive casts.

This is standard Lancashire and Yorkshire Railway foundry practice, and gives a tough close-grained casting with good machining qualities.

Steel Foundry.—"The steel foundry is to-day as necessary an adjunct to a large railway works as an iron foundry, the successful introduction of the small converter having made this step a desirable one in many obvious ways." The author wrote this sentence, among others, in a long description of lay-outs of locomotive works. In 1911* he found it copied word for word with much of his other matter in the chief prize essay to the Indian Railway Conference of 1920, and published in *The Railway Engineer* of October, 1920. Evidently, therefore, Indian authorities are quite ready to confirm to-day his opinion of ten years ago.

With the Siemens furnace much has been done. Acid and basic methods alike share pride of place in producing material eminently suitable for various requirements, and, for heavy castings especially, these furnaces rightly continue in favour. But the introduction of the small converter has opened out a wide field, which may briefly be said to be in the manufacture of castings of any weight, from a few pounds up to 2 tons, and may include light sections even bordering on ornamental design. Whilst the open-hearth processes will also deal with castings ranging from light up to 10 tons or more, there is not the same elasticity in the making of smaller castings, particularly in the softer grades, and weighing less than 1 cwt., which is so excellent a feature of the small converter. Open-hearth plants, to work economically, must run continuously; heats of metal must be tapped and got away both day and night. Where steel ingots are required, these, of course, can be made during the night shifts, leaving the day heats for

* "Modern Railway Working," Blackie and Co.

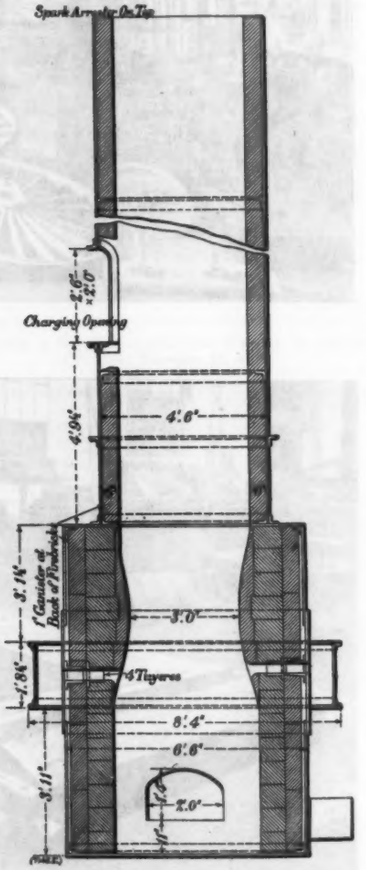


Fig. 6.

castings. But for the usual steel foundry these conditions do not hold. Ingots are probably seldom required, and only one heat per day will be got out, thus entailing serious waste of heat in the furnace, which is only working at half its duty.

The relative advantages of electric furnaces and small converters for steel castings may be debated at length. Before doing so an inspection of Table V, showing an ordinary day's work with a side blown 2-ton converter may be interesting. It shows a yield of molten metal for castings, of 22 tons 16 cwt., obtained in one converter in a day of 11 hours 13 minutes start to stop, and three such days, allowing alternate days for preparation of moulds and necessary repairs, may be taken weekly.

The plant consisting of cupola, converter and air blower to give 4 lb. per square inch is shown in Fig. 5. When not blowing, the plant is shut off and no heat losses accrue for stand by time, beyond preliminary heating up of the converter by coke and blast for a few hours prior to starting up.

The table shows the metal composition and coke consumption of standard practice, the main drawback to the process being the melting of pig and scrap steel with coke in the cupola. By this means an increased sulphur contents is present in the product, compared with the electric furnace. The limit of sulphur in British Standard Specification No. 24, of 1921, for steel castings, is not exceeding 0·07. This is satisfactory in use, and

CONTROL IN A RAILWAY IRON AND STEEL FOUNDRY.

TABLE IV.—SERVICES CONTROLLED BY THE LABORATORY.

——	Control.	Record.
Compressed air, 80 lb.	Methods of driving, repairs and upkeep of spare parts, 1 steam and 1 electric compressor	Simmance continuous tape chart instrument. Budenburg gauges for indicating pressure are fixed at various parts of the air main.
Blast air, 25-in. W.G.	Bristols recording gauge and mercury column.	
Steam, 80 lb.	Simmance continuous tape chart instrument	Simmance tape chart record. Allocation for each department made out every half-year.
Producer gas	Orsat gas sampling apparatus to determine CO, H, CH_4, CO_2, N, O, constituents in the gas. U-tube used for fan air pressure. Whipple temperature indicator for temperature of gases passing through the flue.	
Waste heat (chimney and furnaces)	Weekly records taken for temperatures, leaky valves, &c., with Whipple temperature indicators. Cambridge single-thread chart instrument is used on the melting furnace chimney stack.	
Hydraulic pressure, 1,000 lb.	Gauge and cut-off mechanism.	
Furnace temperature (pyrometry)	Platinum rhodium thermocouple pyrometers are attached to each furnace where annealing is done. Temperature is recorded by thread chart instruments and wall type indicators, made by the Cambridge Scientific Instrument Company.	
Electric current	Elliot recording ammeter is periodically put in motor circuits so that no motor can be overloaded without the fact being known.	Card records are kept of all repairs and duration of stoppages for each motor.

MATERIALS CONTROLLED BY THE LABORATORY.

——	Control.	Record.
Coal and Coke	Each consignment entering the works is sampled and sent to the department requiring the specified class of fuel. Cupola tests.	Approximate analysis of coal and coke are taken to determine volatile matter, fixed carbon, sulphur, ash moisture and B.Th.U.
Tropenas and Siemens-Martin steel	Tested for tensile and bend tests. Cast-iron, tensile and transverse tests. (Microstructure and analysis). A small bunion from every heat of metal cast is sent for analysis.	To British Standard Specifications No. 24—1921. Eggertz process for carbon and manganese done on melter stage, full analysis at the Laboratory.
Sands and refractories—mixtures and tests. Alloys, oils—Laboratory analysis.		

RESULTS OF EXPERIMENTS ON TEST BARS.

Cylinder No.	Tensile Tons/In.	Brinell No.	Analysis. C.C.	G.C.	Si.	S.	P.	Mn.	Breaking Load on Bar, 36" × 2" × 1"	Total Deflection.
									tons	in.
1	17·6	212	0·60	2·98	1·65	0·187	0·675	0·64	1·42	0·37
2	16·2	223	0·68	3·20	2·10	0·170	0·812	0·72	1·56	0·36
3	17·4	201	0·64	3·12	1·71	0·148	0·712	0·70	1·74	0·37
4	15·1	212	0·58	3·20	1·60	0·146	0·703	0·72	1·91	0·32
5	16·0	212	0·66	3·04	1·60	0·154	0·610	0·55	1·75	0·35
6	17·6	212	0·66	2·86	1·60	0·146	0·584	0·77	1·63	0·28
7	17·9	212	0·57	2·76	1·94	0·19	0·70	0·64	1·73	0·32
8	18·9	217	0·60	3·06	1·65	0·165	0·681	0·71	1·59	0·27
9	17·8	212	0·64	3·00	1·82	0·19	0·586	0·71	1·82	0·39
10	18·1	223	0·68	2·98	2·09	0·170	0·450	0·72	1·63	0·35
11	16·4	212	0·54	2·82	2·07	0·17	0·70	0·70	1·87	0·36
12	18·2	223	0·65	2·82	2·1	0·16	0·64	0·66	1·99	0·40

TABLE V.—RECORD OF BLOWING DAY—TROPENAS PROCESS—MAY 4, 1921.

Analysis of Pig-Iron Used.

	C.C.	G.C.	Si.	S.	P.	Mn.
E.N. Nos. 1 and 2 mixed hematite	0·15	4·32	4·20	0·033	0·044	1·60
Carnforth No. 1 hematite	0·44	3·82	1·64	0·026	0·025	0·90

Sulphur and Phosphorus in Steel Scrap Used.

	Sulphur.	Phosphorus.
Highest	0·082	0·064
Lowest	0·030	0·014
Average of nine estimates	0·056	0·039

Blow Number.	Amounts of Material used. E.N. 1 & 2 Pig-Iron.	Carnforth No. 1 Pig-Iron.	Steel Scrap.	Analysis of Cupola Metal. C.C.	G.C.	Si.	S.	P.	Mn.	Finished Steel. C.	Si.	S.	P.	Mn.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
646	50	10	40	0·64	2·82	2·24	0·088	0·048	0·74	0·28	0·14	0·067	0·065	1·10
647	50	10	40	0·50	2·98	2·52	0·093	0·045	0·90	0·12	0·32	0·078	0·064	1·00
648	30	30	40	0·45	3·16	2·44	0·09	0·043	0·87	0·24	0·14	0·075	0·061	1·00
649	30	30	40	0·60	2·96	1·96	0·088	0·041	0·66	0·13	0·33	0·070	0·059	0·80
650	30	30	40	0·57	2·80	1·67	0·088	0·051	0·60	0·18	0·36	0·07	0·058	0·81
651	30	30	40	0·61	2·86	1·90	0·093	0·047	0·56	0·16	0·36	0·067	0·051	1·00
652	30	30	40	0·54	2·68	1·49	0·093	0·042	0·76	0·22	0·11	0·056	0·055	0·90
653	30	30	40	0·55	2·94	1·76	0·107	0·044	0·59	0·18	0·11	0·067	0·048	0·80
654	30	30	40	0·54	3·00	1·70	0·088	0·047	0·56	0·18	0·33	0·067	0·049	0·75
655	30	30	40	0·55	2·76	1·79	0·107	0·048	0·59	0·15	0·14	0·067	0·045	0·88
656	30	30	40	0·55	2·96	2·20	0·107	0·046	0·62	0·21	0·34	0·062	0·056	0·94

Blow Number.	Metal Charges in Cupola. Pig.	Scrap.	Time of Blow. Start.	Finish.	Duration of Blow.	Converter Air Pressure.	Cupola Blast Pressure, Inches of Water.	Tests. Tensile.	Per Cent. Elongation on 2 In.	Cont. of Area.	Bend.
	t. c.	t. c.	h. m.	h. m.	min.	lb.		tons per sq. in.		per cent.	deg. W.F.
646			6 37	7 18	41	3½	21				
647			7 44	8 28	44	3½	21	28·0	37·5	47·2	180
648			8 52	9 37	45	3½	21				
649			10 5	10 43	38	3½	21	30·3	30·0	44·4	180
650			11 7	11 34	27	3½	22	30·6	32·5	44·4	180
651			12 0	12 30	30	3½	22	31·2	32·5	49·6	180
652			1 30	2 5	35	3½	21				
653			2 35	3 0	25	3½	21				
654			3 30	3 50	20	3½	21	B.S. Specifications.			
655			4 30	4 55	25	3½	21	26·0	15·0		
656			5 30	5 50	20	3½	21	min.	min.		90
	17 14	11 12									

Total weight of charge, including alloys ... ... T. 29 ct. 15 qr. 2 lb. 5
Total weight of yield 22 16 0 6
Per cent. loss ... ... 23·43

Total hard coke consumed (all from stock) ... T. 5 ct. 3 qr. 2 lb. 0; per ton of metal melted ... cwt. 3 qr. 2 lb. 4
Total limestone ... ... 0 4 0 21; per ton of metal melted ... 0 0 16
Coke analysis ... ... 0·775 sulphur.

thousands of railway wheel centres, locomotive and motor castings have been made to this specification. Silica brick linings last 1,000 blows before re-lining, the converter being patched with ganister after each day's working. The design of the cupola, Fig. 6, for melting charges of 50 per cent. hematite pig-iron and 50 per cent. steel scrap, is worthy of more than passing attention.

Losses in Working.—An actual day's loss of metal in Table V, up to the point of metal in the casting ladles is 23·4 per cent. This includes the cupola 7½ per cent. and converter 16·9 per cent., the latter being made up of 6·5 per cent. loss by combustion of C, Si, and Mn, shown in the analysis, together with the 10 per cent. loss for oxidation and metal in the slag.

The working of the six months' period under review came out as follows :—

	Steel. Per Cent.	Iron Castings. Per Cent.
Good castings	53·0	77·5
Heads, gits and skulls...	23·4	15·0
Cupola and converter loss	23·5	7·5

Total net output : 746 tons, details being given in Table VI on the following page.

The articles on a locomotive which may conveniently be cast in steel, amount to over 50 designs.

One of the advantages of the small converter is its flexibility, any grade of casting from dead soft electrical steel to high carbon material being readily made. During the war this plant manufactured 10,000 steel castings for Woolwich Arsenal and received among others the following appreciation :—

ROYAL GUN AND CARRIAGE FACTORIES,
WOOLWICH, S.E.,
December 5, 1918.

DEAR MR. HUGHES,—Now that hostilities have ceased I must tell you how fully we, in this department, appreciate the excellent services which your workshops at Horwich have rendered to us for the country. The thoroughness which has always characterised the efforts of your staff in meeting abnormal demands, which we have been compelled to make from time to time, is a matter for congratulations, and I should be glad if you would be good enough to convey my thanks to them for the hearty co-operation and help which has always been extended to us so readily in times of need. If anything deserves special mention it is the work of your steel foundry, which has supplied this department with something like 820 tons of castings during the past four years, and it gives me great pleasure to record the fact that the quality of the castings supplied to us surpassed anything we have obtained elsewhere; added to which deliveries have been maintained at an excellent rate throughout.

Yours sincerely,
(Signed) W. DENNIS, Superintendent.

Steel Ingots.—Table VII shows a week's output of a 20-ton acid melting furnace cold charged by hand, 14 charges being cast of railway material for springs, tyres and sections. Two melters (one 20 tons, one

14 tons) are installed, though trade depression only allows one to work at once since the armistice. Eleven to twelve heats per week are regularly obtained, which speaks volumes for the control exercised. The furnaces are gassed from old Wilson 4-cwt. producers modernised by the use of motor fan for air blast and exhaust steam taken from adjoining source. Eight gas producers in all fire the whole foundry, melters, annealing furnaces, core ovens, mould domes—five being allocated to the melters whose coal consumption for the week's output in Table VII was 5·64 cwt. per ton of ingots. The half-yearly coal averages 7·89 cwt. per ton. Naturally such figures are not obtained without care in gas analysis, and steam saturation temperature of blast, and they show what a small plant can do, even with old gas producers. The output is a source of satisfaction to management, men and trade union officials, and as the writer put it at one of his joint meetings of these three bodies, it is a result of good men, well-designed furnaces and watchful management.

Table VI.—*Output of Steel Castings—July to December, 1920.*

Quantity.	Particulars of Castings.	Total Weights.
		tns. cwt. qr.
854	Wagon wheels	144 0 0
613	Carriage wheels	111 2 0
65	Motor bogie wheels	19 15 0
67	Buffer rams	2 10 0
14	Mud C. Seatings	0 4 2
244	Hornblocks	15 6 0
51	Frame cross stays	4 7 0
11	Motion Plates	2 12 0
94	Auto couplers	5 18 0
8	Tube plate liners	0 18 0
109	Piston crossheads	6 7 0
84	Brake shafts	8 7 0
26	Boiler seatings	4 4 0
248	Swing light castings	9 6 0
52	Ramps and Jim Crows	5 2 2
45	Motor carcases	11 0 0
25	Flanging and hammer blocks ..	5 5 2
6	Helical wheels	0 11 1
38	Foundation rings	19 19 0
44	Locomotive wheels	57 0 0
102	Radial slides	5 13 0
3	Passenger wheels	4 1 0
6	Commutator sleeves	0 15 0
12	Inside motion brackets	2 18 0
35	Expansion link brackets	9 12 0
16	Valve spindle cross guide	0 15 1
36	Frame stays	3 7 0
13	Saddle plates	1 4 3
39	Outside motion bracket	8 2 0
38	Rocking lever	4 16 0
200	Crossing blocks, &c.	6 7 2
	Other castings (mostly small work)	264 18 2
	Six months total	746 0 0

The foundry is equipped with thermocouple pyrometers of the wall type, and the continuous indicator design made by the Cambridge Instrument Company, which have given good results. For portable work the Whipple resistance pyrometer and the Féry type are used. It is not within the scope of this address to go into detail on these matters in view of the amount of literature available. Details of the pyrometers in use are annexed.

Technical Instruction.—It is an axiom that the greater interest a man takes in his work the more will he accomplish both in quality and quantity with less effort of mind or body than when he barely realises the reason of his craft skill, and every assistance is given to youths entering the foundry to acquire knowledge of the technical side. From his experience in conducting the metallurgical classes at Horwich the author has noted how well a young man will respond to any interest taken in him by his manager.

Table VII.—Particulars of Heats from No. 2 Melting Furnace. November 18 to November 25, inclusive (1920).

Date Charged	Time of Charge.	Time of Tap.	Total Time.	Cast No. S.	Class of Steel.	Analysis. C.	Si.	S.	P.	Mn.
	h. m.	h. m.								
Thursday afternoon, November 18	2 45	10 0	7¼	907	Spring	0·60	0·07	0·05	0·05	0·59
Thursday night, November 18 ..	10 45	7 15	8½	8	Mild	0·19	0·06	0·05	0·05	0·57
Friday morning, November 19 ..	8 0	5 0	9	9	Mild	0·18	0·06	0·05	0·05	0·64
Friday afternoon, November 19 ..	5 45	2 15	8½	910	Mild	0·19	0·06	0·04	0·05	0·60
Sunday night, November 21 ..	6 0	3 0	9	1	Tyres	0·59	0·25	0·04	0·05	0·81
Monday morning, November 22 ..	3 45	12 15	8½	2	Tyres	0·60	0·29	0·04	0·06	0·78
Monday afternoon, November 22	1 0	9 15	8¼	3	Tyres	0·59	0·26	0·04	0·05	0·77
Monday night, November 22 ..	10 0	6 15	8¼	4	Tyres	0·61	0·26	0·05	0·05	0·79
Tuesday morning, November 23	7 0	3 30	8½	5	Tyres	0·60	0·26	0·05	0·05	0·85
Tuesday afternoon, November 23	8 0	6 0	10	6	Tyres	0·60	0·26	0·05	0·05	0·85
Wednesday morning, November 24	6 45	3 0	8¼	7	Tyres	0·64	0·26	0·05	0·05	0·85
Wednesday afternoon, November 24	3 45	12 45	9	8	Tyres	0·65	0·26	0·04	0·05	0·80
Thursday morning, November 25	1 30	10 15	8¾	9	Tyres	0·63	0·26	0·04	0·05	0·85
Thursday morning, November 25	11 0	8 45	9¾	920	Tyres	0·59	0·25	0·04	0·05	0·85

Total number of heats = 14. Yield = 301 tons.
Total coal consumed = 85 tons, or 5·64 cwt. per ton of output.

The melters (20 tons) are of the usual Siemens regenerative design, with chief characteristics of :—

Size of hearth per ton, 9 sq. ft. to 10 sq. ft.
Port areas, gas to air : ratio 330 : 850 sq. in.
Regenerator chambers—free space in chequer work equal to 10 times size of port areas.
Gas valve (Kirkham), 21 in. diameter.
Air valve (Butterfly), 30 in. diameter.
Chimney, 75 ft. (one furnace only), 1 in. draught.

To prevent short circuiting of air draught, the usual air opening on top of the butterfly valves is closed, and air is admitted to the flues through a second valve close to the furnace wall, and therefore well away from the suction of the chimney. This gives an altogether keener pull on the hearth. In addition to control of fuel and metal supplies in charge and yield, waste heat is graphically recorded by a pyrometer of the Cambridge Instrument Company. This is found of great assistance in detecting warped valves, choked regenerators, leaking brickwork and waste of fuel generally.

Annealing and Pyrometry.—To obtain the best results in toughness, uniform grain, and consequent life of a locomotive casting, heat treatment is resorted to. Castings of quite ordinary design will comprise thick and thin sections united by radii, or suddenly emerging one from the other in ways which the designer cannot entirely control. Such sections cast in a mould naturally undergo varying periods of cooling before all the heat is abstracted, and follow the laws of contraction by exerting corresponding "pulls" on those parts which are hottest and least able to withstand such treatment. To relieve them, thin brackets of metal are left at these parts. The result is that, without distinct cleavage planes or fractures being actually present, a complex casting will contain within itself a series of strains, and these must be relieved and put into a state of ease before use.

Further, a casting having cooled down from a molten condition would naturally have its composite crystals in the coarsest possible condition, equivalent to the coarse fracture of an overheated or burnt steel. Such a casting then would be in the worst condition to resist shock, and to obviate these effects they are annealed.

Annealing consists of reheating to a temperature sufficient to break up the existing structures as viewed microscopically, with subsequent slow cooling down, and in all cases fractures of castings must show fine grain. The temperature to be obtained is a variable quantity dependant upon the percentage carbon of steel, whilst the duration of the anneal is regulated by the size of the casting. For locomotive castings, a temperature of 900 deg. to 920 deg. C. gives the best results, gas-fired furnaces being used. The length of anneal varies considerably; small articles such as hinges and brackets, especially if of low carbon, are sufficiently annealed after 8 hours' heating. For locomotive wheel centres, 12 hours' heating by gas, at the temperature named, with further slow cooling, is found to give good results both in tests and service.

The main use for pyrometers is in the annealing of malleable and steel castings. Record charts can be produced for each batch of castings treated, and the chart acts as an incentive to the furnaceman. For this purpose records are preferred to the simpler indicator type. For iron castings, pyrometers have not found a regular use beyond observations in the works laboratory for special investigation, and in the foundry for optical measurements of ladle temperatures.

By a selective process based on their shop records and technical work, apprentices are given tuition without loss of wages on two afternoons weekly to advance their studies commenced in the evening classes, and short addresses on their craft by assistant foremen, during working hours, and visits to other works, are of frequent occurrence. An apprentice supervisor is appointed to give his whole attention to the training of boys in their vocations. Youths are given opportunity for works training for periods of three months at a time in the foundry metallurgical department, test room and laboratory, inspection and progress departments.

For very many years the Lancashire and Yorkshire Railway have provided a fully-equipped technical school, where foundry apprentices among others have acquired knowledge leading to success in the final or honours course of iron and steel manufacture set by the City and Guilds of London, or in metallurgy. Many of them wishing to train for managerial positions are then passed on to more specialised courses at Manchester University, or School of Technology, one well-known professor of metallurgy having received his training in the foundry and school at Horwich, and many process managers.

These second and third-year metallurgical classes are attended by many students from works in the neighbouring towns, in addition to the apprentices and pupils in the locomotive works. One student, a Cambridge graduate, has this year passed the City and Guilds final examinations in iron and steel manufacture, a third-year course in his first year.

From this source the investigating and process assistants are appointed with good results, these men passing to posts including foundry forman, chief of testing department, chemical laboratory, and locomotive works manager, the author having been appointed acting works manager of the entire locomotive works at Horwich during the late war, 1914–19.

Pyrometers.

No.	Instrument.	Type of Couple.
1	Cambridge double-thread recorder	Platinum - platinum rhodium.
1	Wall type indicator	" "
1	Cambridge single-thread recorder, fitted with two-colour mechanism to give two records on one chart	2 Platinum-platinum rhodium.
1	Wall-type indicator	Platinum - platinum rhodium.
1	Cambridge single-thread recorder ..	Platinum - Platinum iridium.
1	Wall-type indicator	Platinum - platinum rhodium.
1	Whipple temperature indicator ..	3 ft. 3 in. platinum resistance; 2 ft. 3 in. platinum resistance; 1 ft. 1 in. platinum resistance
2	Wall-type indicators (spare for interchanging other recorders while under repairs)	Platinum - platinum rhodium.
1	Féry radiation pyrometer.	
1	Wedge optical pyrometer, range 0 deg. to 500 deg. C.	

The detail given above shows that any foundry apprentice or specialised pupil keen on advancing himself, may expect to acquire either professorial rank or high administrative office in railway work, according to his bent, and Cambridge men in particular will be interested in Horwich practice revealed by the accompanying "mention in despatches."

Inspection of Searchlights,
G.H.Q., B.E.F., France,
July 29, 1918.

"It is reported for information that up to the present 73 skew gear controls have been received from England for use with anti-aircraft searchlight projectors, and with the exception of eight these have all been manufactured by the Lancashire and Yorkshire Railway Company.

"It is obvious that very great care has been taken in the selection of the material, and that all the parts have been most accurately and carefully machined and fitted by the Lancashire and Yorkshire Railway Company. Exceptional interest must have been taken in the production of these controls, and it is thought that perhaps the railway company referred to above might be thanked accordingly.

"The officers and men concerned have been most anxious to obtain the controls with as little delay as possible, and it is reported that they have very materially increased the efficiency of the searchlights.

"(Signed) W. C. H. Pritchard, Lieut.-Col., R.E.,
"Inspector of Searchlights, France."

DESIGN AND CONSTRUCTION OF U.S. PASSENGER STEAMERS.*

By Mr. E. H. Rigg, Member of Council.

To one who loves his profession it is hard to imagine a title which opens up greater possibilities in the way of a chance to contribute a worth-while paper to our Transactions. The subject could be well extended to the dimensions of a large book, so many and so intricate are the avenues opened up. Without going to such lengths, it will be my endeavour to review the field as it appears to-day to one engaged in the design and construction of such ships. Our new merchant marine is replete with cargo carriers of all kinds, except perhaps in refrigerator ships, of which there are only a few; it has remained for a comparatively few yards to be privileged to build the nucleus of our hoped-for post-war passenger fleet in the vessels of the Old North State and American Legion classes; a fleet also contributed to by captured German ships, reconditioned after the war.

A paper by Mr. Peskett on the design of steamships from the owner's point of view (T.I.N.A., London, 1914)† is well worth reading before commencing a paper such as this. His experience has been ample, and his association with a fleet of the first order lends weight to his views. His paper opens up to view an excellent summary of the conditions to be faced in determining types and sizes. It follows this up by some helpful solutions of given cases, particularly considered cases being the historic Lusitania, Mauretania and Aquitania; in other words, the development of the Cunard fleet up to the war. The important task of satisfactorily drawing up a typical specification and contract is ably covered by the same author before the same institution‡ one year ahead of the above quoted paper; this also gives a clear exposition of that particular and important problem. The designer of passenger ships, especially large ones, should be familiar with the ground covered in both these noteworthy papers; the Atlantic is no barrier to their usefulness.

The main items influencing a design are about as

* Paper read at the twenty-ninth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 17 and 18, 1921.

† See Engineering, vol. xcvii, page 537.

‡ See Engineering, vol. xcv, page 880.

follows: Number and type of passengers; availability and nature of cargo; economical speed; safeguards to be adopted; harbour limitations, chiefly draught, but also length; radius of action, distance between ports; type of propelling machinery and fuel; climates to be traversed; governmental regulations; mail contracts and payments. Before any figures can be put together these features must be all assessed and their quantities determined. No serious attempt has been made to put them in their relative order of importance, but that given above is roughly correct. Governmental and classification regulations, being fairly uniform, do not, as a rule, influence designs fundamentally in the sense that an American ship would vary greatly from a British or a French one to meet similar demands otherwise; there are differences, however, which must be taken into account before actual detailed work is undertaken. Recent international conferences on tonnage, bulkheads, freeboard, lifeboats and manning and such matters tend towards a uniform settlement of these fundamentals which is altogether desirable. In the opening sentences of this paper, reference was made to the magnitude of the task. In order not unduly to lengthen the paper, ocean-going ships will be primarily considered, such being the field to which our attention is mainly directed; other types, however, will not be neglected.

Ocean Passenger Vessels.—The great problem of to-day is to design and build ships that can be made economically satisfactory; first costs of two and one-half to three times pre-war figures, soaring passage rates, people taxed to the limit and otherwise hard hit by the greatest calamity of all times, unrest and strikes, fleets sunk or in bad shape due to the war, all combine to make a real problem for owner and builder. There is no doubt that the strike habit, recently if not now prevalent in the premier shipbuilding country of the world, is driving away repair work and holding up new construction to a point where the premiership is coming within measurable distance of transfer; the fact that the strike habit is no monopoly of any one country helps to hold matters more in a state of balance and *in statu quo*. Whatever may be true of cargo ships—for it is true that the general falling-off of trade is as much responsible for the lines of tied-up ships as the end of the war and the completion of war-building programmes—is not true of passenger ships. We are still short of these vessels; the lack of new orders and holding up of old ones is solely due to economic conditions, high first costs and inability to pay the rates necessarily asked, chiefly the former.

As is shown later, ocean passenger ship design is being influenced profoundly by causes arising from the war.

The economics of general cargo ships have lately formed the subject of several able papers. Mr. Robertson recently has contributed two to our society and four or five such papers have been recently read in England and Scotland. With these as a guide, backed up by experience—which is always invaluable—it is hard to justify a poor result in the field covered. When it comes to passenger carrying we have an extension of the same problems. Speed in cargo carrying above 11 knots is not easy of justification in normal cases; it becomes of the essence in passenger ships. The method of solution adopted by Mr. Anderson in his 1918* and 1920† papers before the London Institution can be used in association with detailed knowledge of the passenger trade on any given route. In practice, the selection of dimensions and speeds narrows down to within close limits in average cases.

The large number of our recently-completed passenger ships which have gone or are about to go into the Pacific Ocean trade calls for comment. Of the sixteen 535 footers and the seven 522 footers, representing a gross tonnage of some 300,000, 12 of the larger and 3 of the smaller have gone into service on the Pacific; of the larger, 2 are still to be allocated, which indicates that the fleets to which allocations have been made are temporarily satiated. The Pacific thus gets 67 per cent. of the tonnage, and there are other indications that our Pacific trade will be large—our interest in China and its development, our nearness to her markets compared with Europe. The Phillippine and the Hawaiian Islands make for commerce with the Pacific coast; our Australian and Japanese trade also calls for passenger and freight services. Then, too, South American trade presents an opportunity awaiting revived foreign trade, improvement in the exchange rate from the foreigners' point of view, improved exporting methods on our part and the working out of the recent foreign trade financial legislation.

Passenger ships were ordered in great quantity in Britain following the war; a large amount of this tonnage has been suspended or cancelled. This suspended activity gives our new ships an opening to get in on the ground floor of the revival, of which signs are now multiplying.

We are struggling with a shortage of trained *personnel* and with some poor engineering due to rushed war conditions; the ships in service have not been without troubles of their own. They will get over those troubles or they will lose the trade to their British and Japanese competitors. Time and tide wait for no man, and trade goes to the fellow who is there to take it. The more one contemplates the situation the more one sees that the hour has struck for an America taking her full place in world affairs as compared with an America of splendid isolation.

Passenger Steamers for Sheltered Waters.—Perhaps nowhere in the world are there such opportunities for lake, bay, sound and river navigation as in America. Our transactions contain many full papers on this subject, and it would be hard to name one who has contributed more to their design and building than has Mr. Frank E. Kirby. The problems are not as complicated as are those of the ocean; draught is usually limited, and lines adapted for high speed in shoal water are not the same as for deep water. Ports are closer and bunkers carried are lighter; fresh water from overboard is often available for boilers, if not for drinking. Cargo is generally carried in relatively small amounts, largely on deck rather than below. Fire risks are severe in these ships and must be seriously studied and minimised. In rivers and canals, bank erosion must be guarded against, and here the experimental tank has come to our aid in studying wave-making. In some recent Hudson River vessels, in particular, wave making has been notably reduced, enabling greater speed to be maintained for the same erosive action or less of such action for equal speed.

Due to the war, probably, there has been almost nothing built lately in this class which calls for comment; with renewed opportunities for such travel let us hope for some new vessels to build. The opportunities for design and decoration of extensive passenger spaces are considerable, particularly in vessels for lakes, rivers and sounds. In the public spaces the large central wells give opportunities for architectural effect not often found in ocean liners. Many of these vessels in the past have been built with too little beam for satisfactory stability results; top decks have been increased or added in order to crowd on more passengers, the accident point having been found in more than one instance, notably the Eastland, in recent years. Some river steamers have found it necessary to set back the rails, thus limiting the passengers who can crowd top decks; also in boats traversing water with points of interest first on one side, then on the other, water ballast chambers in the wings have been fitted so that the engineer can fill the same on the off side and empty it again after passing the particular point, such as West Point Military Academy on the Hudson.

Paddle-wheel propulsion still holds its own for this type; the experimental tank is invaluable for correctly locating the wheel centre to avoid disaster due to wave profile and wheel not meshing. Paddle wheels have been recently severely put to it to hold their own with screws working in tunnels as a means of propulsion for shallow-draught vessels. We have also seen a revival in proposals made many years ago which looked to the fitting of fixed guide blades abaft the revolving blades to recover some of the energy of the propeller race. It can be said that tunnel screws have definitely established their claims.

Passenger Refrigerator Trades.—The carriage of meat, fruit and dairy products in cold storage has become a very large trade during this generation. American, Australian and Argentine fresh meats are now eaten on European tables in large quantities, and at the same time the horrors of the live cattle trade are a thing of the past, thanks to refrigeration. Tropical fruits are enjoyed in northern latitudes in increasing quantities. Perhaps the chief feature which leads to the passenger-refrigerator ship is the speed desirable for refrigerator ships—the less time on the voyage the better. Also, these cargoes are bulk rather than deadweight cargoes, which means that larger ships are needed for a given weight. Both these considerations lead to the desirability of increasing the revenues by carrying mails and passengers. The great white fleet of the United Fruit Company, one of our strongest and best-managed lines, is undoubtedly a good illustration of this. There are also some large meat carriers fitted with accommodation for passengers, a valuable revenue being derived therefrom to pay for the speed in excess of 11 knots, which is about an economical speed limit for cargo-carrying vessels of moderate to large dimensions.

Trend of Design; Ocean Passenger Ships.—As an indication of this, the following classes of ships designed in part and estimated on, since January, 1918, by one large shipyard in this country, may be of interest:—

Length between Perpendiculars.	Speed.	Cabin Passengers.	Deadweight.
feet	knots		tons
400	15	100	4,350
600	18	1,460	15,000
450	23	410	3,700
500	16	250	9,000
550	15½	1,830	8,650
475	14½	445	5,530
360	13½	50	4,100
450	16	255	6,000
400	15	200	3,900

Several of these ships had third-class and steerage passenger accommodation in varying extent, three-quarters were transferable to a large extent, so only the first and second-class quarters and permanent third-class cabin accommodation have been listed above, thus giving a better guide to characteristics of the vessel. In the 600-ft. ship, accommodation for 700 third-class passengers in permanent cabins is included; also in the 550-ft. ship 1,160 such third-class are included. The list thus gives the real cabin accommodation, whether first, second or third class.

The 23-knot ship was primarily intended for a coastwise run, but also for trans-Pacific, so that she is correctly rated as an ocean-going ship, though whether the full 23 knots would be maintained on a deep-sea run is problematic.

The average length works out at 465 ft., a very modest figure for nine typical passenger ship designs, and, omitting the 23-knot ship, the speed averages 15¼ knots. It would seem fair to regard the high speed of 23 knots in a 450-ft. ship as quite exceptional. It is worth noting that 15¼ knots is quite modest for a 465-ft. ship and that it checks up with the tendency noted above. These ships are uniformly of the shelter or shade-deck types with ample superstructures amidships and generally with forecastles. Fully half these inquiries were from foreign owners; an encouraging sign. Besides the above listed vessels, other inquiries not involving detailed design work were received; they lined up well as to type with those given and do not change the indication of the trend.

As regards proportion, the old and lingering tendency to narrow beam is at last giving way; it is not going fast, but it is yielding to two influences; the old ship that capsizes when handling light in harbour, unless ballasted, evidently is a nuisance, and has plagued a good many people. The war has served to emphasise a tendency already to be seen by those on the inside, and that is to give more metacentric height and listen less to the discomfort of passenger talk that was so prevalent. Personally I feel that you have to go to metacentric heights far higher than the prevalent 18 in. or 24 in. in order to get appreciable discomfort; in other words, get all the data you need by studying stability and rolling features in successful ships, then adopt a G.M. about twice pre-war standards and you will have a ship that is not too stiff. I cannot claim enough sea-going experience to dogmatize too strongly, though I do believe that the talk of discomfort has been overdone, having been to sea a little in almost all kinds of vessels, principally with a high G.M.

The other cause leading to more beam is the finding by Admiral Taylor and other investigators working in the experimental model basins, to the effect that more beam can often be given a ship and enough coal saved by fining up (for the same deadweight) to pay for the little extra steel weight generally involved. In other words, the bugbear of narrow beam is under investigation and is getting to be in a bad way. It must, however, be noted that stability considerations due to the flooding of a damaged ship point to caution in increasing beam. War experience has given us a large volume of data concerning the behaviour of flooded and sinking ships, and this, intimately associated with subdivision lessons, will ultimately give us safer all-round ships.

An interesting group of papers bearing on the subject of this paragraph was read at the engineering conference in London last summer;* the size of docks and ships was discussed, also cargo-handling facilities. What is said elsewhere as to the future of the large liner, written by the author prior to the reading of a summary of these London papers, is borne out; after the passing of present difficulties, these authorities look for the return of the large liner, advocating dimensions for docks of 1,150 ft. by 130 ft. by 45 ft.

Bulkhead Subdivision.—This subject has been very much to the front since the spring of 1912, when the world was shocked by the disaster which befell the Titanic. Our own transactions, as well as those of the Institution of Naval Architects, have been favoured with many able papers on the subject; lessons of the war are now at hand, so that detailed treatment of the subject is neither necessary nor does it properly belong in this paper. As the question stands to-day, we have the results of the international convention to work on together with the British Bulkhead Committee's Report, followed up by such papers as those of Abell, Benvenuti-Chamberlain, Danny, Dickie, Donald, Finlay, Foster-King, Gatewood, Hovgaard, Lovett, Orlando, Robb, Wall, Webster and Welch. As several of these gentlemen have contributed two or three papers, it is obvious that the above list contains much valuable data. We also have governmental and classification society instructions to guide us. The war has taught us that a spacing of 40 ft. is about the minimum desirable to cover war risks, as a closer spacing gives torpedoes a good chance of blowing out two bulkheads at one explosion. There has also been considerable discussion concerning the merits of the one, two, or three-compartment design of ship, compared with the factorial grading of subdivision. Before the convention is finally adopted, it appears quite safe to say that a review of the whole situation is in order. Passenger ships should, by common consent, be made safer than the "pre-Titanic" regulations required, and already much has been accomplished along these lines.

Our Pacific coastwise passenger steamers should have more attention in respect to bulkheads. A rockbound and apparently foggy coast has given us two major accidents this year, the Governor and the Alaska; these vessels were both built before 1912. These accidents have been preceded by others of a similar nature in past years. The accounts, as we read them in the east, generally run about the same as to the speed at which the ships go down and the by no means light casualty lists which follow their going. It is not intended to cast any reflection on Pacific coast navigation. Here we have vast extents of sandy shores which eliminate the rock-hitting risk, except in the north; also the danger spots are better known, due to longer acquaintance. The casualties on a rockbound coast are bound to be more severe and sudden, which is another way of saying that we should pay more attention to efficient bulkheading. It is proven that good bulkheading will save many a ship altogether, also that the ones it does not finally save it will often keep afloat for hours and thus give full time for rescue work to be made effective.

One-Class Liners.—As it has developed since the war, this is a relatively new idea and one which has much to commend it; on a large, high-speed liner the *de luxe* accommodation very naturally and properly occupies the best of the available space. Second class is generally aft and quite limited as to public rooms and promenades. Third class comes in below first, and the forward deck is

* See ENGINEERING, vol. cv, page 323.
† See ENGINEERING, vol. cix, page 460.

* See page 38 *ante*.

the airing space, this being frequently so airy that none but ablebodied seamen can navigate with safety. What better way to solve the problem than to carry the passengers willing to pay the rates on the larger and faster mail steamers and to give the benefit of the best parts of other ships to people willing to pay cabin rates for passage in slower ships, run at lesser operating costs and carrying relatively more freight. The idea works out well in connection with the moderate-sized ships built since the war; it gives greater flexibility in operating fleets, taking care of seasonal changes in business conditions.

The Cunarder Albania is a case in point, she being a post-war ship and destined for the North Atlantic service, the home waters of the *de luxe* liner. It should be noted that vessels carrying top-rate passengers only are not here specially referred to; needless to say such ships are neither new nor rare, the old Atlantic Transport Line between New York and London being a good example. If ocean travel is to get back to pre-war peace and comfort, this experiment will be watched as one of the means of bringing back in improved form the comfort, and indeed the actual chance itself, of travelling to a great many people who cannot afford present first-class rates but who still constitute a large body that is only too anxious to travel and willing to pay fares a little nearer pre-war best average rates. It should also be noted that the White Star Line has further extended the one-class liner idea and have in service the Vedic, a ship carrying only third-class passengers and all in cabins; the best parts of the ship are theirs, and there is every facility for self-respecting humans to travel in comfort and decency. Several other examples could be quoted, but the above will serve.

The one-class ship, or rather the ship without class distinctions, is something that deserves to succeed, and let us hope to see it do so. Another point which should not be lost sight of is that the one-class liner works in well with moderate first cost of ship. In these days the struggle is to keep first costs and passage rates in some relation that will stay together in at least comparative peace. With only one class of passenger per ship a smaller ship will answer our purpose; it is all available for these passengers, and we are going to have less difficulty in getting promenades in the open air and deck area in the quarters. In fact, the one-class ship looks like one shrewd answer to post-war problems.

Length.—In 1912 Mr. J. Foster-King presented some very interesting diagrams to the International Congress of Navigation in Philadelphia. These pre-war indications of the trend are extremely valuable at this time; the diagrams, produced to 1920, enable performance and estimate to be compared. For the largest type of North Atlantic liner, the 1,000-footer was indicated; in the Aquitania and Majestic (ex-Bismarck) we find pre-war justification of the forecast. Coming down to the longest types for general first-class passenger service and selecting some 14 of the most noteworthy post-war designs actually launched, we find an average length of 585 ft., the greatest being 650 ft. and the smallest 505 ft.—five only being 600 ft. and over. Mr. King's curves gave 775 ft. for Atlantic liners, excluding the leviathans, and 650 ft. for general first-class liners; it is clear that the 1912 outlook has not been realised, a point also clearly brought out in several other directions; the fact that the 585-ft. average includes several Atlantic liners tends further to show the reduction, the figure with which it should be compared being intermediate between 650 and 775, in a ratio difficult to get at. It seems reasonable to say that large passenger ships have been shortened by 100 ft. from considerations arising out of the war. The chief influence at work is the high cost of ships, which makes it a serious question with owners as to whether they can charge passage rates high enough to realise on their investment without killing the business of passenger carrying by reason of the inability of people in sufficient numbers to pay such rates.

The 1,000-Ft. Liner.—Apart from and in extension of the references made to this length of vessel under paragraph headed "Length," some further remarks appear to be in order. As is generally known, a committee was formed under Government auspices some while ago to look into this question. The subsequent long spell of idleness at her dock of the Leviathan, after invaluable troop service, is rather a damper on 1,000-ft. ardour; nevertheless, it remains a fact that a vessel of this length was well in sight when the war broke out. At least one design has been seriously started and pushed to the point of a study of schedules, terminals and rail facilities, of a full set of outline plans, of extensive calculations and of detailed lay-out of proposed propelling machinery. This design contemplated going to Panama Canal lock limiting sizes at one step; it is not necessary to say that the two ships would run between New York and London, starting and arriving at deep-water harbours at each end and with rail connections to New York and London.

It can be safely said that the engineering features, especially when high tensile steel is used, present no difficulties which cannot be met. The problem is one of economics entirely. Is the route able to support such liners without Government aid in some form? If not, what justification can be advanced for claiming such aid? We can, as shipbuilders and engineers, say that, as far as our profession is concerned, we stand ready to furnish the ship and her propelling machinery just as soon as other considerations justify such a vessel. As a matter of record and interest a few particulars of the design as it stood in its earlier stages may be of interest:—

Length overall	1,000 ft.
Breadth	105 ft.
Depth	76 ft.
Deep load draught	38 ft.
Speed at sea, knots (depending on weather)	30 to 32.
Shaft horse-power (maximum) ...	150,000
First-class passengers	1,100
Second-class passengers	800
Third-class passengers	1,400

The propelling machinery at first contemplated was electric drive; with the large battle cruiser Hood at sea, the path has been opened to the full consideration of the claims of a geared turbine drive. The oil fuel required for a round trip is in the region of 11,000 tons. This would be too much for the ship to leave this side with; the answer would be to leave here with oil for the trip over and half-way back, taking in oil for the other half of the returning voyage on the other side before leaving. At full load this vessel would have a total deadweight of about 12,000 tons. There would be no freight as is generally understood but mail, bullion and express matter would be carried; also such small consignments of special freight as could be handled during the time necessary to refuel and reprovision the ship at each end. In the early days, when this length was first proposed, the scoffers, technical and otherwise, were legion. Not so now; technical scoffers at once merely proclaim their ignorance. On the financial side there is ample room for hesitation, and there the matter must rest for a while, to be taken up again as the world recovers from the effects of the war.

Depth and Draught.—This subject is one calling for special mention. It can be stated at once that the draughts adopted for large liners are not those that the naval architect would choose if he had a free hand; neither are they the ones dictated by considerations of the limitations of steel as a shipbuilding material. Terminal harbours and canals are the main deciding factors, and while a discussion of harbours, existing and projected, is not within the scope of this paper, nevertheless it may be noted in passing that the improvement and deepening of harbours are again being taken up seriously, the extensions to the facilities of the port of London recently opened being a case in point.* The late Sir W. H. White contributed a valuable paper bearing on this subject, among other things, to our society in 1911; Sir J. H. Biles has shown in several papers the advantages of increased draught in large carriers, also Lord Pirrie has contributed to our knowledge on the subject. In order not to take up space with repetitions, the interested reader is referred to these papers and to the report of the Canadian Royal Commission on Oversea Communications, dated 1914, an extremely valuable document the importance of which has evidently been masked by the war. Suffice it to say that the economics of the ship can benefit by increased draught up to the point where such increase imposes excess costs on harbour authorities, which would have to be passed back to the ship in the form of increased and excessive harbour charges.

A really first-class harbour should nowadays have a depth of at least 40 ft., and Lord Pirrie advocates 45 ft.; with such depths and corresponding draughts of about 37 ft. 6 in. to 42 ft. 6 in. economics of transport are available. Mr. F. J. King's forecast in 1912 referred to above under "Length" is worth noting; his figures gave a 1920 draught of 36 ft. 6 in. for Atlantic liners and for average passenger ships. The predicted Suez Canal depth of 30 ft. came very close to being a mean draught for such ships, which showed steady increase up to a 25-ft. to 34-ft. range. Draught increases relatively and actually more slowly than length, it is hardly necessary to say.

The Panama and Suez canals are bound to exercise a profound influence on the draughts of passenger liners the figures for which now stand as follows: (1) Panama.—A minimum depth of 40 ft. in the canal, with 40 ft. in the Atlantic and 35 ft. in the Pacific approaches at mean low water, which means an available draught of about 38 ft. (2) Suez.—At present the available depth is 32 ft. and permissible draught is 30 ft.; the authorities are dredging for 34 ft. 6 in. and 31 ft. figures respectively. It is to be noted that Suez has gradually been deepened by dredging from 19 ft. in 1870 to 32 ft. in 1920.

Liners of the future will probably not be able to avail themselves of all the draught economically desirable, for we are now approaching the region of excessive dredging costs in certain harbours. Another big factor in restricting draught is the River Plate; many vessels now trading there on a 26-ft. 6-in. limit could well have been designed for 30 ft.

Speed and Power.—Looking back on the not so distant days when it was necessary to plead the advantages of experimental tank work, it is gratifying to reflect on the conditions of to-day. The last decade has witnessed a decided modification of attitude. In addition to resistance and estimated horse-power curves, the experimental work now being done on model propellers, both in free water and behind ship models, calls for commendation. This is a field that has been opened up comparatively recently. In addition to deep-water conditions, attention is given to shoal water problems, so important in connection with inland navigation. Destroyers at high speed some time ago proved that the two forms of navigation were different. I well remember the case of one of the last of our coal-burning destroyers; a chart showing the results of some Denny shoal-water experiments was on board, but the practical people looked at it askance until they tried to get 24 knots, in water entirely too shallow, for the same power as in deep water. They knew something was wrong, and finally it began to dawn on them that there might, after all, be something to that blandly ignored chart, so they decided to haul off into deeper water, with the result that all promptly went well. It is also known that lines suitable for deep water are not necessarily good for shoal water.

Coming to passenger liner speeds, before the war we had reached 26 knots for all the way across the Atlantic, in the Lusitania and Mauretania. In the later Cunarder Aquitania we see a reduction to 23 knots, while the large White Star boats ran in the neighbourhood of 21. About the maximum for the long routes to the Cape, India and Australia was 18 knots. Referring to the paragraph headed "Trend of Design," it is evident that moderate speed will be a feature of new construction for a while. Referring to the paragraph headed "Length," the average speed for the 14 post-war designs for all trades there discussed is about 16¼ knots with a range of from 14 knots to 18 knots; it must be noted that in three or four cases the speed was not obtainable. It is, however, obvious that speed in representative liners has been cut down from that which obtained before the war. It is seen that the evidence is all for moderate speed, even on the North Atlantic, which is another way of saying that this particular route is contenting itself at present, at least as far as new ships are concerned, with vessels that average up well with those on the general routes of world travel, instead of the accustomed 21 knots to 23 knots of the old days. In the attainment of better results, the competition in systems of propulsion does, and will to a greater extent, contribute to a lower consumption of fuel per horse-power. The problem is threefold—lower resistance, better propellers, and more economical power plants. The question of inexperienced engine-room forces has troubled us lately, but should become less prominent as conditions improve; men gain experience and faults of design and construction are eliminated.

The new C. P. O. S. liner, Empress of Canada,* completed this year, has a speed that is decidedly in advance of the present trend. She will be the largest vessel on the Pacific, according to current reports, being about 120 ft. longer than the American "Legion" type. She is announced to have made well over 20 knots on the mile and to be designed for 18 knots in service. One report credits her with 25 knots on the mile; if so, the owners are to be congratulated on having a vessel which lacks nothing of Atlantic liner standards except extreme size. Her entry into the service will be felt among competing lines, who will have to look to their laurels; the turn of speed she is capable of will be very useful when it becomes again economically practicable to burn the fuel.

Speed has an effect on design that is not clear at first glance. The piling up of deck-houses is a noteworthy feature of many modern vessels. In the next paragraph we discuss very high-speed liners of warship type as far as dimensions and proportions go. High deck-houses would not go well on such vessels; they are one solution of the ventilation question that cannot be ignored, for we all like an airy room. There is no doubt that ventilation plays a big hand in the popularity of a ship; in tropical runs it is of the essence. For such vessels all modern advances in the ventilation question will have to be utilised, but there is no reason to doubt the ability of the shipbuilder to meet the need, once it is realised how great it is; American warship practice has proved that. I believe that, during the war, the British paid us the compliment of appointing a committee to study our methods in this respect. It will mean a few less rooms and larger ducts, fans in duplicate to avoid breakdown and a margin in boilers and dynamos over the present practice. The claims of the water-tube boiler over the Scotch for high-speed ships have made good to such an extent that they will feature more largely in future ships.

The Cost of High-Speed.—Apart from the initial cost of the machinery necessary to obtain high speed, the fuel bills become very high. For example, consider a 750-ft. Atlantic liner of varying speeds from 15 knots up to 30 knots; such a ship would have a beam of about 90 ft. and a deep draught of 36 ft. Call the voyage 3,000 miles, which gives a round figure close enough for our purpose. Remember, too, that as speed goes up cargo carrying ability goes down and passengers, mails and express matter become ultimately the sole sources of revenue, outside subsidy. The figures are about as follows:—

Speed at Sea (Knots).	S.H.P.	Total Dead-weight (Tons).	Cargo Dead-weight (Tons).	Oil Fuel, One Way (Tons).	Cost of Fuel, One Way.
					dols.
15	16,000	29,000	26,500	1,450	26,100
20	38,000	23,000	19,400	2,550	45,900
25	73,000	14,000	9,000	3,900	70,200
30	113,000	5,800	—	5,000	90,000

Such a vessel would carry some 600 first, 450 second and 1,000 third-class passengers and would be quite big enough for speeds all the way to 30 knots. It is seen that the 30-knot ship carries nothing but passengers, mails, stores and bunkers, which is the logical outcome of this investigation. Oil fuel is figured at 6 cents a gallon or 18 dols. a ton; a figure which, of course, is subject to variation. It would be well to pursue this further, but the above table will show that, with cargo capacity falling from 26,500 tons to nothing and fuel costs rising from 26,100 dols. per voyage to 90,000 dols., the economics of the large ship are not easy. It is clear, however, that the greater number of voyages per year for the 30-knot ship must also be taken into account. This may be summarised somewhat as follows (see table on next page).

The days in port are somewhat indeterminate, due to uncertainty in time necessary to load and unload. The times given are estimates only and are subject to change to suit terminal conditions; they should be fairly close. Allowance has been made for docking, overhaul, &c.,

* See Engineering, vol. xcii, page 718.

* See Engineering, vol. cx, page 241.

passengers and cargo are taken at only 85 per cent. full, averaged over the whole year. The compensations coming to the fast boat show up in this table; she will carry more than twice the people per year at, naturally, much higher rates per person. It is also clear that the 15-knot ship does not deliver enough extra freight to compensate for the fewer and lower rate passengers

Speed of Ship (Knots).	Days at Sea, One Way.	Days in Port, at each End.	Days for Single Trip.	Single Trips per Year.	Passengers per Year, at 85 per Cent. Full.	Cargo (Tons) per Year.
15	8½	9	17½	17·3	20,270	3,897,000
20	6½	7	13½	22·6	39,550	3,726,500
25	5	5	10·0	30·0	52,500	229,500
30	4½	3	7½	42·0	73,500	—

carried. With everything lined up properly, the 30-knotter will make 21 round trips in a 300-day working year, *i.e.*, a round trip every two weeks. Two such ships, laying off during the two bad months to avoid the worst weather, could command the cream of the travel.

They are not excessive in size, and even if they only make 20 round trips per year, due to miscellaneous bad weather and sometimes taking the longer southern route to clear ice and fog, such ships equipped for first and second cabin only would each average 45,000 passengers per year, which at, say, 250 dols. per person comes out at 11,250,000 dols. against a fuel bill of 3,800,000 dols., which is not so hopeless. The obvious temptation is to pursue this further, but I am afraid that I shall have to refer it to the Committee on the 1,000-ft. ship, due to lack of data on the cost of operating vessels of this size. May I commend this 750-footer to that committee as a step well worth considering in our further progress towards the solution of the problem of the modern Atlantic liner?

A recent report credits the Aquitania with transporting a total of over 90,000 persons east and west-bound in her first full year on the New York run. She is rated at a capacity of 3,238 passengers and 23 knots speed, and this is believed to be a record performance. The speed stated is for coal burning; under oil she should be capable of about a knot more. Comparison with the figures given above indicates that 90,000 passengers transported in a year is a very good performance.

Another interesting point in the speed question is that of increasing speed in vessels of moderate dimensions. Now and then this question comes up; it is well known that speed combined with reasonable comfort is associated with size in some way not strictly definable. The Mauretania gives us one point, namely, a length of 760 ft. and a speed of 26 knots; a proportional length for 30 knots would be 1,000 ft. We now want to inquire if such length is necessary for this speed. Sir W. H. White held, if I read his 1911 paper* correctly, that the Mauretania represented the maximum of length necessary for her speed, also the maximum practicable speed for the North Atlantic. The Aquitania, which he did not live to see go into service, represented an increase in length and a decrease in speed. The later Paris represents a decrease in speed on about the same length as the Mauretania, the evidence thus not being conclusive.

A maximum speed-length ratio of unity has been a general guidance rule for ocean passenger ships for many years. With lighter machinery, oil fuel and other advances, the speed question again becomes one for renewed study and discussion.

The following table shows the fuel savings possible for high speed moderate dimensioned vessels:—

Length of Ship (Feet).	S.H.P. at 25 Knots.	S.H.P. at 30 Knots.
600	56,000	137,000
700	64,000	119,000
800	68,000	131,000
900	80,500	153,000
1,000	91,000	163,000

These figures represent smooth-water powers plus 10 per cent. for the 25-knotters and plus 15 per cent. for the 30 knotters. The dimensions dependent on length follow average merchant practice, except that the beam on the 1,000-footer has been limited to suit the Panama Canal lock dimensions to 102 ft. It is clear from this table that a Mauretania at 30 knots would bear out Sir William White when he says that no greater length is necessary.

Destroyers attain a speed-length ratio of 2, but it cannot be claimed that they attain it with comfort and safety except in quite moderate weather. European cross-Channel steamers obtain a ratio of 1·50 with greater safety and comfort than destroyers; where the line must be drawn for the North Atlantic is our problem. The ships listed above cover a range of from 1·225 for the 600-footer to 0·95 for the 1,000-footer at 30 knots. The Mauretania's figure is 0·95 m. From this it is submitted that the 750-ft. ship of 30 knots, as proposed above under this heading, is practicable, providing the fore ends of the ship and of the midship deck erections are especially designed and strengthened with a view to avoiding deck damage in weather not otherwise severe enough to make slowing up necessary. All fittings and deck openings before the bridge would need to be of special design. The table above for varying lengths is calculated on a somewhat different basis from that given at the beginning of this paragraph, somewhat different proportions, coefficients, and powers. The two tables were prepared from different aspects but remain substantially comparable.

The question of powers to be expected if very fast liners of warship types were to be adopted is interesting, and is another side of the question that should be investigated. The table of powers varying with length and speed given above covers merchant types developed from current liner practice; the following covers some of the ground as indicated to us by warship practice:

Mean displacement..	10,000	20,000	30,000	40,000
Full displacement ..	11,500	22,750	33,850	45,000
Length, feet ..	585	735	850	930
Breadth ..	58·5	73·5	85	93
Mean draught ..	19·5	24·5	28	31
Mean speed, knots ..	29	32½	35	36½
Total E.H.P. ..	27,500	61,000	97,250	135,000
Total S.H.P. ..	50,000	112,500	177,500	247,500
Oil for 3,000 miles ..	2,300	4,700	6,800	9,100
Days on voyage ..	4·31	3·85	3·57	3·42
Passengers	875	1,100	1,275	1,400

The proportions and speed both render large and high deck-houses out of the question; the passage would be short and promenades would have to be arranged on the quarter deck aft and on one deck amidships well protected from spray. Fast yachts have already been built on destroyer lines, so that liners on cruiser lines are only a logical step, and one that has been discussed before.

The speed has been taken at a 20 per cent. advance on previous general practice; the time on a 3,000-mile run in moderate weather is also given. In the powers given a 10 per cent. margin for sea speed is allowed over a measured mile performance. The bunkers work out at quite large figures. It can be assumed that oil fuel is obligatory, coal handling would be well-nigh impossible both on board and alongside. These bunker capacities are high, but not impractical. Taking only first-class passengers and allowing 1½ per foot length, we get the numbers given in the table. The longitudinal coefficient is 0·58 and the mid area 0·90 for all lengths.

It is seen that the increase from 29 knots to 36½ knots cuts one day off the voyage. As said elsewhere, this branch of passenger-ship design is most fascinating; full plans, however, involve an amount of work beyond the scope of this paper, and it is hoped that these few remarks will be of interest as well as of some value. It is submitted that a full design along the lines of recent experience in battle-cruiser and aircraft-carrier practice is worth while.

As regards weights, it is clear that warship practice rather than merchant would have to be followed for machinery design; the absence of armour, torpedo protection; battery and ammunition weights being utilised on deck erections, passenger accommodations and bunkers.

It must be remembered that some of the British battle cruisers during the war made successful passages of the Northern Atlantic at a very high rate of speed. Particulars of these voyages, made during the war, are not generally known, but it is safe to say that valuable information was obtained thereby.

(To be continued.)

* See ENGINEERING, vol. xcii, page 718.

STEAM PIPE EXPLOSION FROM WATER HAMMER ACTION.

THE Board of Trade have issued, under the provisions of the Boiler Explosions Acts 1882 and 1890, a report of a preliminary inquiry made by Mr. I. F. Blenkinsop, one of their surveyors, with regard to the circumstances and cause of a steam explosion which occurred on August 25, 1920, at the New Hall-lane Mill, Preston, in the occupation of Messrs. Paul Catterall, Son and Co. (1920), Limited. Fortunately no fatal result ensued, but one man was somewhat scalded.

The pipes, which were new, having been made by Messrs. John Spencer, Limited, Globe Tube Works, Wednesbury, the previous March, formed part of the main steam line leading to a new engine which had recently been installed at the mill. The steam line was made up of a number of lap-welded steel pipes, 9-in. internal diameter, $\frac{5}{16}$ in. thick, with screwed-on flanges, 16-in. diameter, jointed together by twelve ¾-in. bolts, having a pitch circle 14 in. in diameter. The mean distance from the boiler-house to the engine stop valve was about 80 ft., but with the several horizontal and vertical leads, the total length of steam pipe used was approximately 146 ft. Hydraulic tests were witnessed on the pipes to a pressure of 280 lb. per square inch by an inspector of the Vulcan Boiler and General Insurance Company, Limited, at the maker's works, in March, 1920. At the time of the explosion, the new engine, boilers and economisers were insured by this company, but the steam pipes were not covered by the policy.

Two lengths of steam pipe in the engine house were damaged by the explosion; one contained a longitudinal crack at the weld, open at its widest part ¼ in., and 9 in. in length, and the other a ragged hole, 7 in. from the weld, which had a maximum width of opening of 4 in., allowing steam and water to escape into the engine-house; the pressure of steam being about 140 lb. per square inch. The explosion was due to water hammer action.

In his report to the Board of Trade, under the heading of "General Remarks," Mr. Blenkinsop writes as follows:

"The work carried on at the New Hall-lane Mill is cotton spinning. Steam is supplied by three Lancashire boilers, each 30 ft. in length, by 8 ft. 6 in. in diameter at a pressure of 180 lb. per square inch, and conveyed to the engine by a long range of lap-welded steel steam pipes, 9 in. in diameter. Before steam reaches the engine stop-valve it passes through a separator, to which is connected a steam trap, suitable for a pressure of 180 lb. per square inch. The power is distributed to the mill by means of rope gearing. A new engine built by Messrs. Yates and Thom, Blackburn, was recently installed, when new steam and feed pipes were fitted; the work was carried out by Messrs. Dryden and Son, Preston, whose workmen were still employed on the plant at the time of the explosion.

"On August 20 and 21 satisfactory preliminary trials of the engine were made. On Sunday, August 22, steam was used for the barring engine to place ropes on to the driving pulley, when it was noticed that the steam trap connected to the separator was not working properly, and it was decided to fit another trap. As a temporary measure, the defective steam trap was removed, and a straight-through drain valve and pipes, 1-in. bore, were fitted, the pipes being led through the engine house door, discharging into the mill yard. These alterations were completed on Monday, August 23, when a final trial of the engine, under load, was made preparatory to supplying power to the mill by the new plant on the following morning. This trial was quite satisfactory.

"At the end of the trial the mill engineer found that he could not shut the engine-house door without removing the end length of the temporary drain, which he removed, and as the discharge from the drain came into the engine-house, he closed the drain valve, leaving it closed overnight. In mill practice the boiler stop valves are left open for heating purposes, steam traps being fitted to prevent accumulation of water in the steam pipes; the steam pipes were formerly well covered with non-conducting material to prevent condensation. In this case the work of covering the new pipes had only commenced, so that the drain valve being shut water would collect in the steam pipes over night.

"The mill engineer states that his first action on the morning of the explosion was to open the engine-house door, connect up the end length of drain pipe, and open the drain valve. The engineer, who was accompanied by the engine-builders' foreman, states that water came out of the drain pipe full bore. He then proceeded to oil the engine prior to starting, and states that about 7 minutes after opening the drain valve he heard a loud rumbling noise which was followed by a rush of steam. At this time there were present in the engine-house the mill engineer, the enginebuilders' foreman and Thomas Scohill, a labourer, who was employed assisting the pipe coverers, and was injured by the escaping steam and water.

"The damaged pipes were taken down and repaired; the pipe which opened out at the weld was fitted with a patch 2 ft. 3 in. long, by 12 in. wide and ⅜ in. thick, riveted only ½-in. rivets at 2 in. pitch. The edges of the patch were electrically welded. The other pipe was repaired in a similar manner, the patch being 2 ft. long by 12 in. wide and ⅜ in. thick. After being repaired, these pipes were hydraulically tested to 270 lb. per square inch and replaced. A new steam trap has since been fitted, which is working satisfactorily."

Mr. Carlton, engineer surveyor-in-chief to the Board of Trade, in his concluding "observations" says: "The conditions obtaining at the time of the explosion clearly point to the action of 'water hammer' as the cause; and it would appear that those in charge of the plant were not apparently aware that the clearing of the water of condensation from a range of steam pipes whilst in open communication with the boiler is a most dangerous practice, and in this particular case the shock of 'water hammer' was most violent."

BENZINE FROM COAL GAS.—A benzine-stripping plant has given very satisfactory results in Wittenberg on the Elbe. New municipal gas works, only of a capacity of 6,000,000 cub. m. of gas per year, were opened in summer, 1920; they had been built by the Berlin Anhaltische-Maschinenbau A.G., at a cost of 85,000 marks, and the addition of the benzine plant raised the cost to 110,000 marks. By April, 1921, when the works had been in operation for seven and half months, 18,595 kg. of benzine had been gained according to the manager's report in the *Journal für Gas und Wasser*, page 643, which worked out at 14 grammes of benzine per cubic metre of gas treated. There were no complaints about the gas, and financially the stripping was a decided success, owing largely to the demand for motor fuel.

BAUXITE IN THE VOGELSBERG, GERMANY.—The bauxite deposits in the Vogelsberg are the only important ones in Germany, and even there the alumina merely occurs in nodules and not in layers that can be quarried. The Vogelsberg is a basaltic high land in Hessen, about 50 km. wide and long, rising to over 2,000 ft., subdivided by radial valleys; the climate is severe and the population sparse. According to Professor H. Harrassowitz (*Metall und Erz*, November 22) the bauxite is the decomposition product of basaltic tuffa and is never found in its primary site in the surface layers where the decay started. The alkalis and alkaline earths and most of the silica and iron have been washed out, leaving alumina and some silica (not more than 10 per cent.), iron and titanium as oxides, and a high percentage of water. The percentage of alumina rises to 58, but is generally not above 50. Chemically the bauxite is hydrargillit, $Al_2O_3.3H_2O$, which is formed as a colloidal gel retaining moisture; the iron and titanium oxides are not in chemical combination with the alumina. The bauxite may be of a cellular structure or more massive like pebbles, a few inches in diameter; they are found in the "red earth"; pseudomorphs of the feldspar originally present in the basalt are frequent. Harrassowitz discusses the genesis of the bauxite without referring to technical features.

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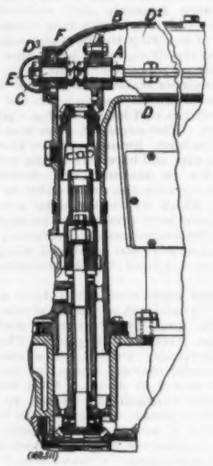
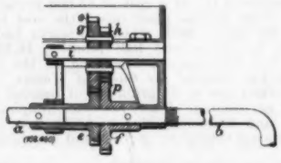
GAS ENGINES, PRODUCERS, HOLDERS, &c.

168,511. Bentley Motors, Limited, London, W. O. Bentley, London, and F. T. Burgess, London. Internal-Combustion Engines. (1 *Fig.*) August 10, 1920.—The object of the invention is to provide the camshafts of internal-combustion engines arranged above the cylinder heads with means for adjusting the position of the bevel or similar driving gear on the camshaft. According to the invention, the camshaft A is adjustable endwise within suitable limits, and is located by adjustable thrust bearings or collars carried by one end of the camshaft and abutting against an abutment wall,



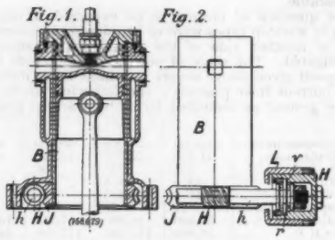
which may be formed on the two parts of a divided casing enclosing the shaft. The camshaft A carries a bevel wheel B and has a short extension piece C which projects through a hole in the abutment wall D^3, which is part of the horizontal split casing D, D^2 enclosing the camshaft. The extension C is screw-threaded on each side of the wall D^3, and each thread carries a nut E and F which acts upon a thrust member which bears against the wall. By slacking one nut and tightening the other, the camshaft can be moved endwise in a simple manner. (*Sealed.*)

168,460. C. E. Richardson, Sheffield. Internal-Combustion Engines. (2 *Figs.*) June 24, 1920.—The object of this invention is to provide gearing between the starting handle and the crankshaft of an internal-combustion engine. The adjacent ends of the crankshaft *a* and starting handle *b* carry spur wheels *e*, *f* which gear with spur wheels *g*, *h* on a secondary or countershaft *i*. The spur wheels *g*, *h* are riveted together,



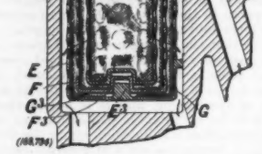
and are such that the crankshaft *a* is driven at twice the speed of the handle *b*. The spur wheels *g*, *h* are mounted to slide on the shaft *i*. To prevent sideplay, the gear wheels *g*, *h* have flanges *o*, *p* that partially enclose the wheels *e*, *f*. In operation, the handle *b*, the gear wheels *f*, *h*, *g*, *e* and the crankshaft *a* are moved endwise to throw clutches (not shown) into connection. (*Sealed.*)

168,629. R. E. H. Daniel, London. Internal-Combustion Engines. (3 *Figs.*) May 6, 1920.—Rotary sleeve valves (for use with four-stroke internal-combustion engines) of the type formed with diametrically-opposite ports which register necessarily with pairs of oppositely located inlet and exhaust passages of the engine and which sleeve valves are swept by the piston and are rotated by worm gearing are provided, in accordance with this invention, with means whereby the worm may be adjusted to vary the timing whilst the engine is running. The sleeve valve B is rotated constantly by the worm H (carried by spindle A) and worm-wheel J. The sleeve valve is adjusted to vary the timing, whilst the engine is running, by a quasi-micrometer screw adjustment which comprises a fixed and internally screw-threaded socket L and, fitting within this, an externally-threaded hollow cap which is rotatable. One end of the worm spindle A is slightly reduced in diameter to form a shoulder against which a ball race device comprising two outer discs fixed to the spindle, a central disc *r* of larger diameter, through which the spindle passes freely, and antifriction balls between the discs. These parts are securely held on the spindle by a nut and lock nut. The central disc *r* fits in the enlarged open end of the externally threaded hollow cap and is held securely against a shoulder *v* by means of a ring nut. The disc *r* prevents movement of the worm spindle *h* in an axial direction. If, however, adjustment of the valve is to be made, this is done while the engine is running by rotating the externally-threaded hollow cap



in one or other direction. The worm H will thus be moved forward or backward relatively to the worm wheel J and will impart a rotary movement to the valve B, and thus set the sleeve valve to give say a later admission or whatever adjustment may be desirable. (*Accepted September* 21, 1921.)

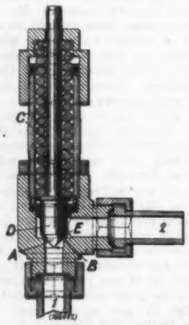
168,734. H. Martin, London, and H. V. Robb, Belfast. Internal Combustion Engines. (2 *Figs.*) July 9, 1920.—This invention relates to filters for use in the lubrication system of internal-combustion engines, and has reference to that type of filter in which concentrically-arranged gauzes mounted upon carriers in the form of cups are supported and located in a casing by means of rims provided around their upper edges. According to this invention, the carriers fit one inside the other, being located by the outer edge of one rim registering in the inner edge of the next larger carrier, while the largest carrier has its rim



engaged by the casing. E, F, G are three concentrically-arranged gauze holders, each in the form of a skeleton bucket. The gauze is soldered to the inside of each holder. Each holder is flanged as at E^2, F^2, G^2 at the top, the flange E^2 resting upon the wall of the casing A, which is part of the crank-case of the engine, whilst F^2 rests upon E^2 and G^2 upon F^2. Each holder is formed with a boss E^3, F^3 or G^3, projecting upwards, the latter pair being recessed on the underside, and the upper projecting part of one carrier enters the recess on the under side of the other carrier. (*Sealed.*)

HYDRAULIC MACHINERY.

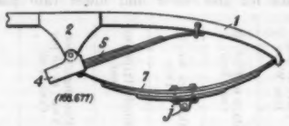
168,442. R. F. Carey, Leigh-on-Sea. Hydraulic Transmission Gear. (1 *Fig.*) June 12, 1920.—This invention relates to hydraulic reversible transmission gear, for instance, hydraulic variable-speed transmission gear in which a pump, either port of which may in turn be subject to pressure, delivers fluid to a motor which can thus be moved in either direction. In hydraulic transmission gear it has been proposed to provide a valve controlling a passage-way connected with both sides of the system, and so positioned with regard to its seating that the excess of pressure can pass from the pressure side into the low-



pressure side. The present invention consists in a spring or weight-controlled valve controlling a passage way 1, 2 connected with both sides of the system for relieving excess of pressure from either side, such valve having a coned or mitred head A fitting a seating B in the passage-way. The pressure from the side 1 of the system acts to force the valve A up against the action of the spring C. The cross-sectional area of the valve stem D is double the area of the seating B, and the pressure from the side 2 of the system acts on a part E, the area of which is equal to the area of the seating. (*Sealed.*)

MOTOR ROAD VEHICLES.

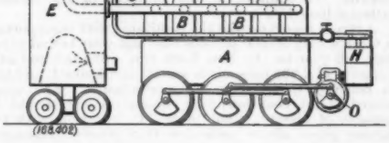
168,677. B. H. Baker, Bristol. Laminar Springing. (3 *Figs.*) June 8, 1920.—Means for springing vehicles made in accordance with this invention comprises an auxiliary spring in the form of a quarter-elliptic laminar spring suitably mounted at its thickest end in the shackle at the end of a main spring which is a half-elliptic spring, the oscillating movement of the shackle occasioned by the primary deflection of the mainspring having the effect of deflecting the auxiliary spring which at its opposite (or thin) end is attached to or bears on the chassis or axle, and thus checks the action of the mainspring without bearing the weight of the vehicle. 2 is a bracket secured to the chassis 1 to which is pivoted a clamping bracket 4. The clamping bracket 4 carries the quarter-elliptic laminar auxiliary spring 5, which is secured at its extremity by a link to the chassis 1. The semi-elliptic laminar or main spring 7 is connected at its thickest portion to the axle *j* and bears at one end on the chassis and at the other end is connected to the clamping bracket 4. In opera-



tion, when the main spring 7 is deflected upwardly it tends to straighten, and thus its effective length is increased. This increase in length tends to turn the clamping bracket 4 about its pivot in a clockwise direction. This turning tendency is resisted by the auxiliary spring 5, but the latter does not bear the weight of the vehicle, and is so arranged that it is not stressed in the position of normal load. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

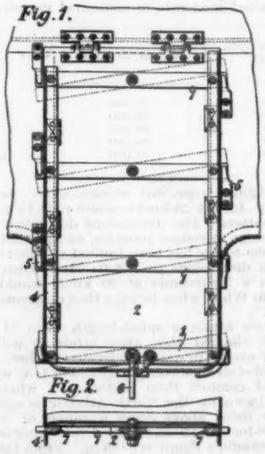
168,402. F. L. Martineau, London. Locomotives. (1 *Fig.*) May 31, 1920.—The invention consists of a locomotive having an internal-combustion engine as its main power unit, a steam generator, and means for using the steam generated in the generator expansively either at the backs of the combustion engine pistons and/or in a separate steam cylinder for starting up and at will thereafter for increasing the total power of the engine. A designates an internal-combustion engine having a plurality of cylinders B, which may operate partially under steam in known manner. E designates a boiler to which the exhaust gases of the internal-combustion engine pass by way of the exhaust pipe C so as to assist in the generation of steam,



and the water jackets of the cylinders may be connected to the boiler so that they form part of the steam generation system. The boiler E is provided with a separate firing means for use at starting and also for overload purposes. A steam engine H may be provided and coupled to the shaft O by worm and wheel gearing, this separate steam engine being used for starting and overload purposes, a stop valve and clutch being provided to enable this engine to be isolated when desired. Steam generated in the boiler E can be passed by way of the stop valve G1 and pipe G to the cylinders B to operate upon the pistons on their sides remote from the combustion chambers, and can, if desired, be passed to the auxiliary steam engine H at will. (*Accepted September* 14, 1921.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c

168,185. R. and W. Hawthorn, Leslie and Co., Limited, Newcastle-on-Tyne, and A. S. Wyber, Newcastle-on-Tyne. Smoke-box doors. (7 *Figs.*) June 12, 1920.—This invention relates to smoke-box doors to which are fitted latch members connected to angles to form a deformable frame and movable by a single actuator into and out of engagement with keepers. According to the invention, the angles in conjunction with pads serve as stiffeners to the door edges. In the particular instance selected for illustration, a series of flat parallel bars 1 is pivoted to the door 2, the pivots being disposed in a line approximately bisecting the door. The bars are connected near their ends to



angles 4 located opposite the door edges, the bars 1 forming with the angles 4 a deformable frame beyond which projects the ends of the bars 1 which function as latch members. The smoke-box is provided about the perimeter of the door opening with a number of wedge brackets 5 engageable by the latch members. To effect simultaneous disengagement of all the latches, the frame is slightly deformed, deformation being effected by manipulation of a lever 6 connected to the lowermost bar 1. The angles 4 in conjunction with pads 7 serve as stiffeners to the door edges, thereby preventing twisting or warping of the door and ensuring complete contact of the door with the smoke-box. (*Sealed.*)